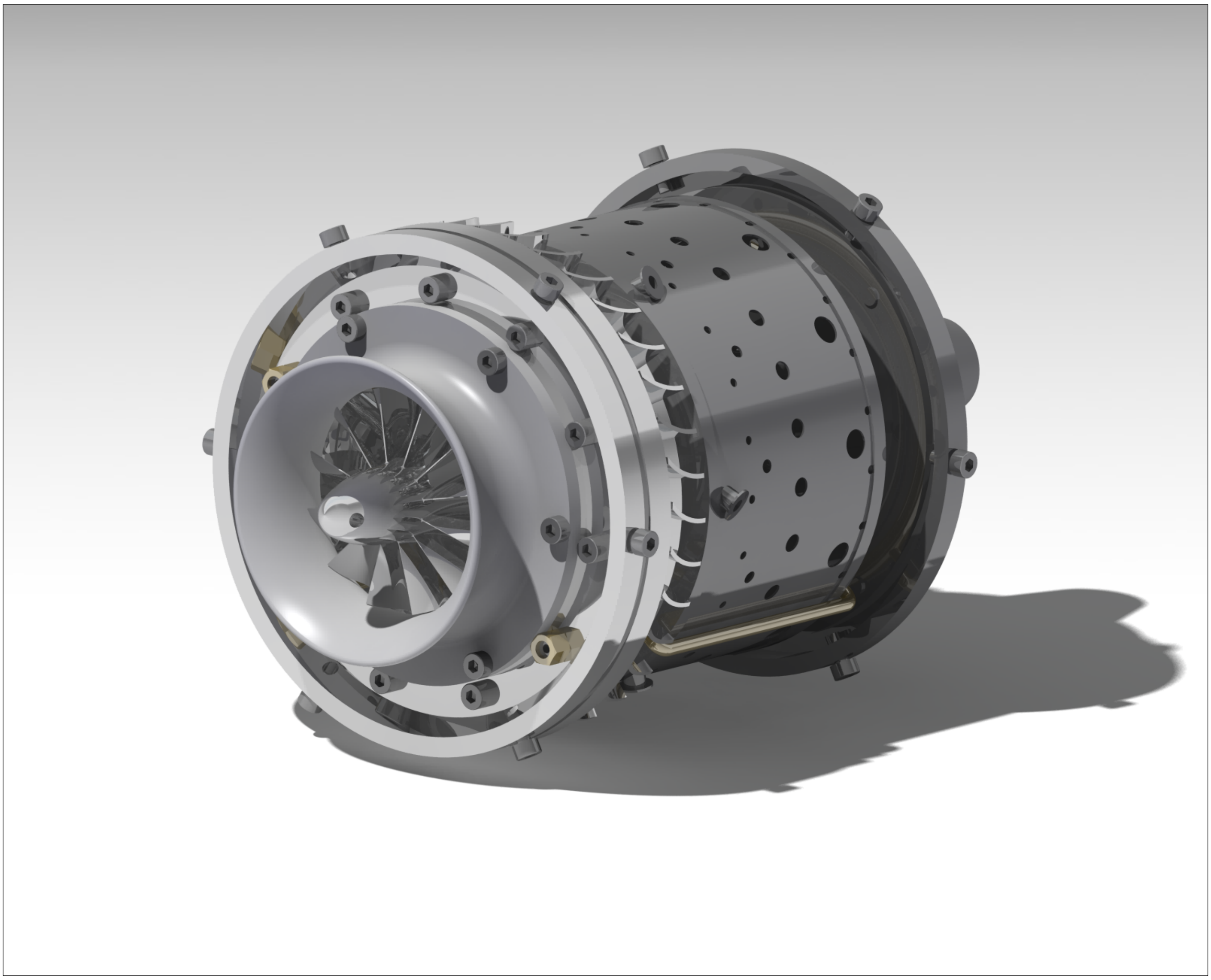

# WREN MW54

Graded Unit

Thomas Dickinson

Project Supervisor: Tony Leslie

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# Research

## Gas Turbine Engines

The Wren MW54 Engine being drafted in this report is a gas turbine engine. The gas turbine was first invented in 1920's and 30's, the first operational turbojet being completed in 1937 by Dr Hans von Ohain, based on Frank Whittle's initial designs (GTBA, 2010). A gas turbine engine is made up of a number of parts; the intake and compressor stage, the combustion chamber, turbines and exhaust. These together allow the engine to turn the air fuel mixture in the engine into useful thrust, using the Brayton Cycle:

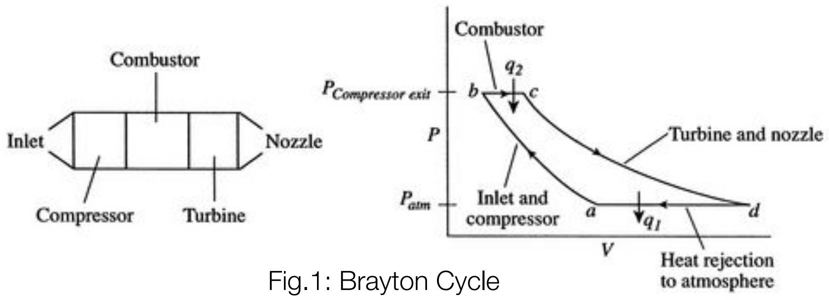



Fig.1: Brayton Cycle

The Brayton Cycle, as can be seen in Fig. 1 is a thermodynamic cycle, which starts with the air entering the inlet, and bring compressed between stages a and b, while pressure increases. Between b and c, the air enters the combustion chamber and is mixed with fuel, where it expands at constant pressure, before leaving the combustion chamber and passing through the turbine and then out the exhaust (nozzle) where it is used as thrust. Other turbine engines may produce thrust differently, such as a turboprop, which produces thrust by driving a propellor.

Another important aspect to note about the gas turbine engine is that it performs "continuous combustion" in that so long as fuel is supplied to the engine, it will run continuously. This can be problematic in the event of an accident, if the fuel is unable to be turned off, as the engine can run for several hours on left over fuel.

The inlet stage of the engine generally forms a pitot style nacelle which, using Bernoulli's Theorem, which states that" for a perfect incompressible liquid, flowing in a continuous stream, the total energy of a particle remains the same, while the particle moves from one point to another" (Codecogs, 2011), means that, as the inlet diverges, the pressure increases, while velocity decreases, as it directly proportional to pressure. This is beneficial as we want pressure to increase, as well as velocity to decrease, particularly in transonic aircraft where the airflow can become too fast for combustion to take place.

The next stage is the compressor stage. In a centrifugal compressor like the Wren MW54 has, the air is compressed radially outwards, where the compressor further increases the pressure of the airflow. The impeller, powered by the turbine, spins, giving the air more kinetic energy, which along with the diffuser then converts into pressure energy using divergent ducts, increasing the pressure using the same principle as the intake (NPTEL, 2006). In the case of the Wren MW54, the engine is a single entry centrifugal compressor.

After the compressor stage, the next stage is the combustion chamber. Here the high pressure air is mixed with fuel and ignited to provide the energy to drive the turbine and propulsion. The exhaust gases then pass onto the next stage; the turbine.

The turbine is what drives the compressor at the front of the engine, and is what allows the gas turbine engine to be a continuous cycle. As the exhaust gases pass through the turbine, the air passes through a series of rotors and stators, the number of stages being dependent on the type of engine. The air drives the rotor blades around, which drives the shaft connected to the compressor, which in turn drives the compressor blades around.

The last stage of the gas turbine engine is the exhaust. Here the gases are accelerated out of the back of the engine, mostly using a convergent duct to increase acceleration.

## Wren Turbines

Wren Turbines have been building gas turbine engines since 1999, and their first engine was launched in 2001 as a set of plans and castings for homebuilders (Wren Turbines, 2013). This went on to become a kit and has since developed into a line of engines. Initially so called because of its compressor diameter of 54mm, the numbering of the series later conformed with the kg of thrust output of the engine. The MW54 (Murphy Wright, the last names of its designers), also went on to have a turboprop model which was released as plans in 2002 and a helicopter gearbox in 2004. The MW54 has since evolved into the Wren 70, 75, Jubilee and finally the 80 and 80 Jubilee with 8.0kg of thrust, while keeping it's 54mm compressor size. The Wren model available for construction in Ayr College is the Wren 70, a 7.0kg of thrust engine.

## CATIA v5r21

Catia, which stands for Computer Aided Three-dimensional Interactive Application, was founded in 1977 by Francis Bernard, as part of the designing of the Mirage. It had it's breakthrough in 1981 when IBM started distributing the software worldwide, and was taken on by companies like Boeing. In the same tar Dassault Systems (3DS) broke away from the aircraft manufacturing part of Dassault; Dassault aviation and became an independent company. Catia is now on v6, but in this model v5r21 is going to be used, which is the most common version running at this point in time.

# Catia v5r20 Usage

## Tools used throughout Catia

### The Mouse

In Catia the mouse has two main uses: for actions such as selecting the starting point for a line and for changing the view of the part. The left mouse button (MB1) is used for selecting tools, starting points and elements. The right mouse button (MB2) is used for bringing up option menus, as well as changing the view, when combined with the middle mouse button (MB3). To do this, first click MB3 then either hold MB2 and move the mouse to rotate the part or click and move the mouse to zoom.

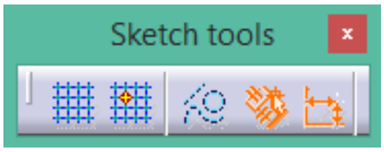
### Update Tool

This tool was used throughout the modelling process, when assembling the final model after constraints had been applied (they did not update automatically) or if a sketch of a part that had already had a sketch based tool applied (e.g. a shaft) was edited.

### Plane

The plane tool allows you to add another plane separate from the original three that you have at the start of the sketch. This is useful for a number of things, and is a requirement for creating a multi-sections solid. You can set the new plane as an offset from an already existing one, or at an angle to it.

## Sketch Tools Used

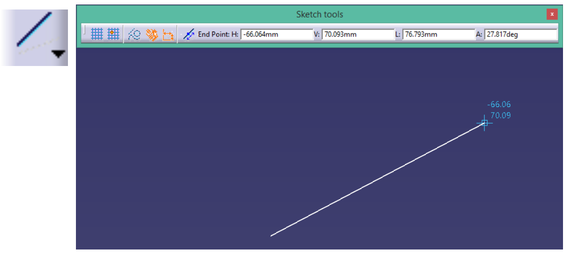



### Sketch Tools

These include the snap to grid sketch tool and switching the line between construction and standard element, which allows makes sketching much easier, for example when creating an arc that has to have a length of chord applied – this is best done using the line tool in the construction element. The sketch tools lie on the drafting screen rather than on the bottom or right toolbar to allow easy access when drafting. They most commonly include distances from the origin but also features specific to each tool, such as the radius for a circle.

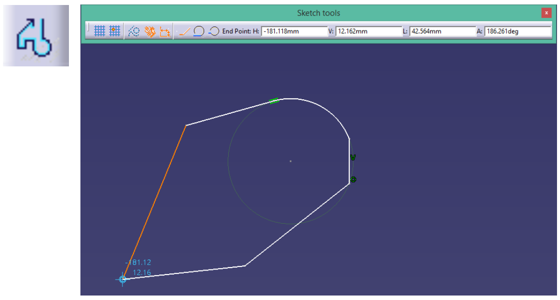
## Line Tool

The line tool is the most basic profile feature available, and once selected is performed by clicking MB1 once for the starting point and once for the end point. The line tool will also lock onto start and end points of other lines among other points.



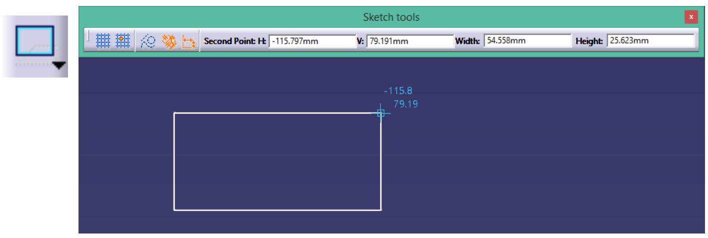

## Profile

This tool is similar to the line tool, except that it allows a number of lines to be constructed consecutively without having to repeatedly select the line tool. To start a profile, select the profile tool, then click with MB1 to start the line. Once an end point has been selected, another line is automatically started until you connect an end point to another point on the sketch (normally the original starting point) to complete the profile. Sketch tools include a three point arc, although this was not used in the project.



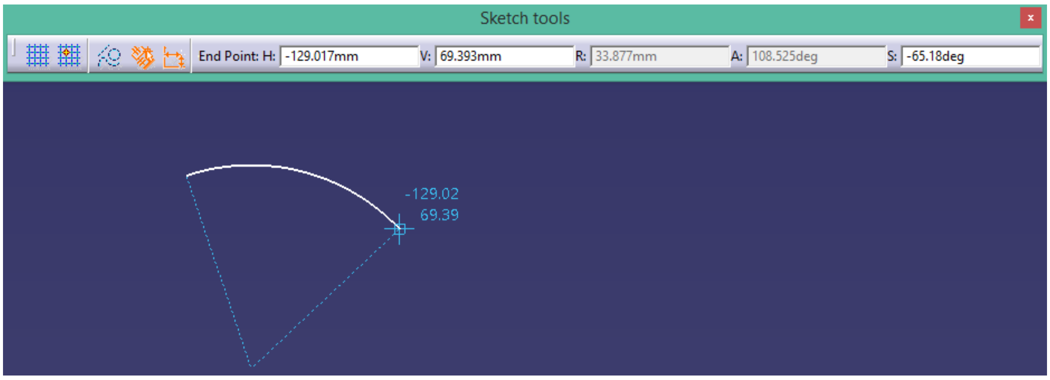

## Rectangle

This is a tool that automatically creates a rectangular profile which horizontal and vertical lines. The starting point and ending point are diagonally opposite each other. To start a rectangle, click with MB1 at the start point and again on the end point at the desired height and length.



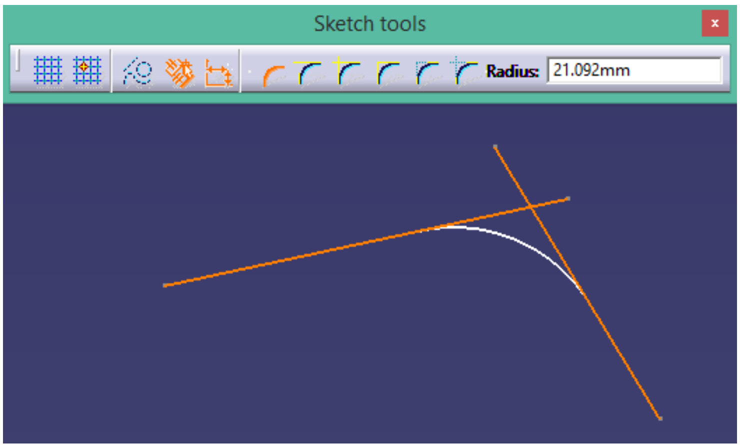
## Circle


This tool creates a circle. To start with, select the tool and then click the start point with MB1. The starting point is the centre of the circle, and the end point sets the diameter/radius of the circle. Sketch tools include setting the height, width and radius of the circle manually. A further option (clicking the black down arrow next to the tool) allows other variations of a circle construction to be selected, although only the arc tool was used in this project which allows an arc to be created. Sketch tools include setting the angle of the start and ending points in regards to the vertical axis, as well as the radius.



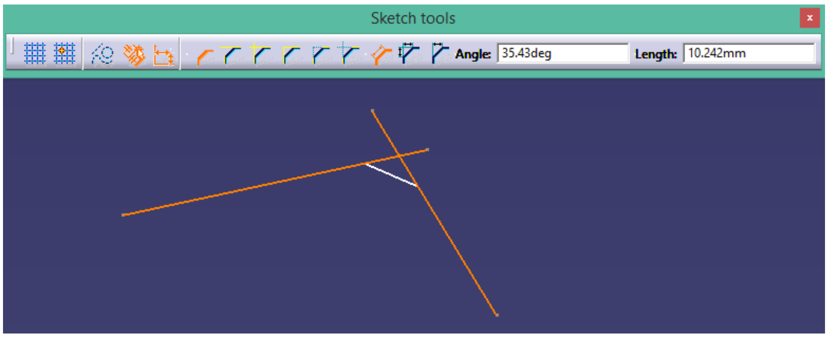

## Corner

This tool is used to fillet two lines to a certain radius. Sketch tools include setting the radius and trim features, such as trimming standard lines, construction lines only etc. First select the tool, then pick the lines you want to corner with MB1 and then determine the radius with either MB1 or the sketch tools.



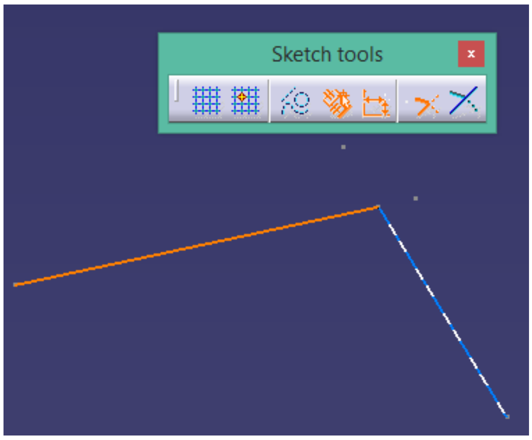
### Chamfer

This tool is very similar to the fillet tool except that rather than a circular fillet, it creates a diagonal line between two lines. Sketch tools include setting the angle, length and trim options. Operating the chamfer tool is identical to the corner tool. The angle is set automatically as standard.



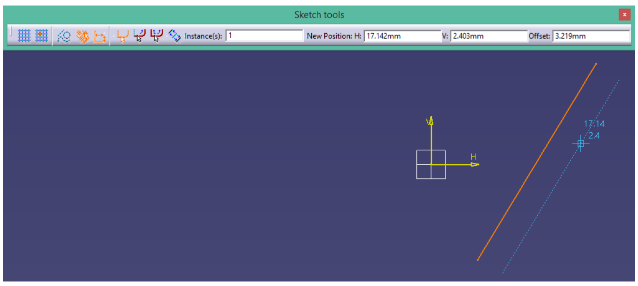

### Trim

The trim tool is used to trim off excess length on lines etc. and is very specific in its use. To trim a line for example, you must select the trim tool, then with MB1 the part you want to keep, then you can trim it longer or shorter. To trim to lines, you must again, select the trim tool, the part you want to keep, of either line, then the other line you want to trim it to.

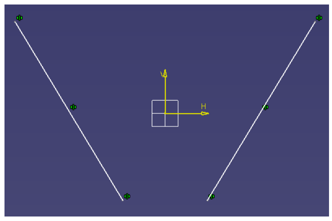



### Offset

This was an extremely useful tool, especially when combined with the "Project 3D Elements" tool, which allows you to create a line parallel to another, at a certain offset, given in the sketch tools toolbar. To create an offset line or spline, select the offset tool, click the original line with MB1 and then select the desired location, or set the distance using the sketch tools. Other sketch tool options include offsets on either side and the configuration of the offset such as tangency (used for splines and arcs).

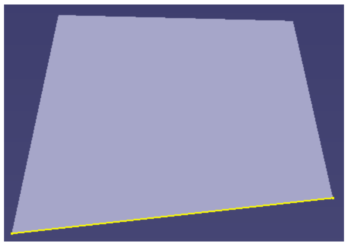


## Mirror



This is another useful tool which allows you to duplicate a draft over an axis, which can be any line on the draft. There are no sketch tools available, you simply select the elements you want mirrored using MB1 and the axis and it creates the mirror.

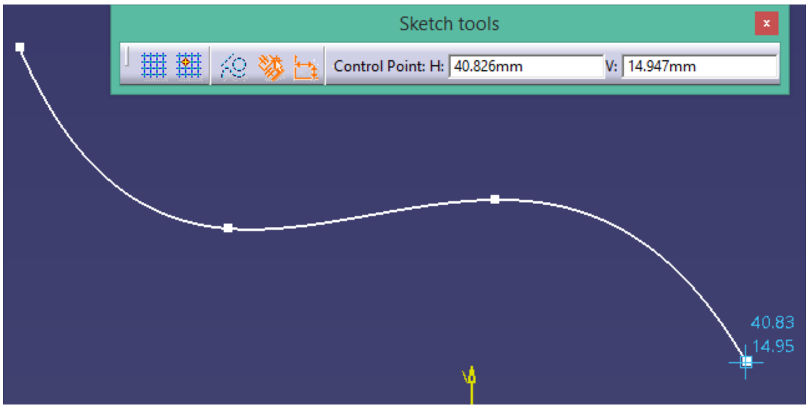
## Project 3D Elements

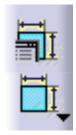


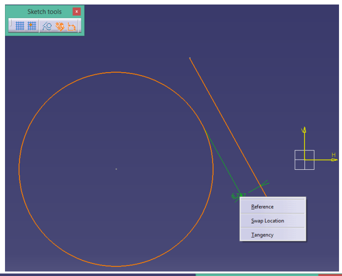
This tool is used extensively throughout this model as it allows lines from 3D models to be taken into the current 2D sketch. Simply clicking on the desired edge or part with MB1 brings either that edge or all the edges into the current sketch. Projected elements are yellow on sketches.

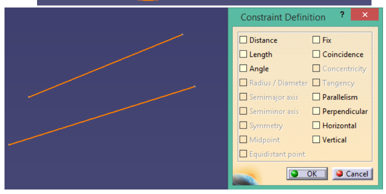
## Spline

This is to create an unstructured curve by connecting dots together. This tool was used to create the aerofoil on the impeller, diffuser and turbine blades. To start, select the spline tool, then draw the points with MB1. A curve will automatically be generated, passing through all points. Double clicking the last point finishes the spline.








## Constraints:

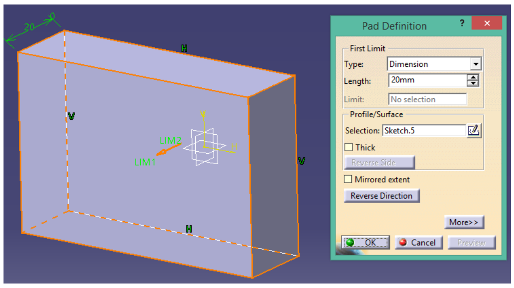
Constraints can be applied using one of two ways; by either using the constraint tool or by using the constraints defined in dialogue box tool:

The constraint tool can be selected at any time. You can then select the line(s) and/or object(s) you want to apply the constraint to with MB1, then click where you want the constraint to be displayed, again with MB1. You can then edit the constraint by double clicking with MB1. The most common constraints this creates are dimensions, such as distance, length, angle and radius, but more complex constraints (such as tangency, parallelism etc.) can be applied by using MB2 before the constraint has been placed and selecting the desired constraint

When you have selected one or more feature(s) that can have constraints, the constraints defined in dialogue box tool becomes selectable. This give you a number of options based one the features selected. Once a constraint has been selected, it will preview it (e.g. selecting the perpendicular constraint will preview the lines at their new positions), before applying it when you have clicked ok. Once the constraint is in place, you can edit it by double clicking with MB1.

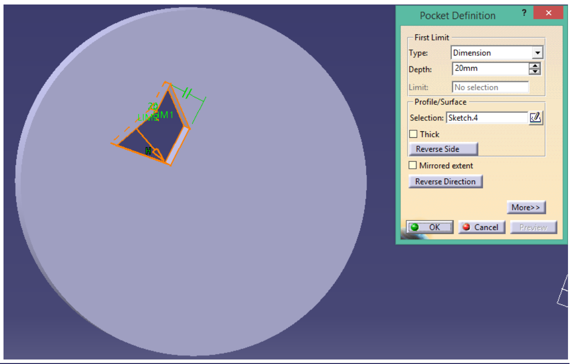
| Name | Constraint |
|---|---|
| **Distance** | Distance between two elements |
| **Length** | Length of an element |
| **Angle** | Angle between two elements |
| **Radius/Diameter** | Radius/diameter of a circle/arc |
| **Midpoint** | Midpoint of a line or edge |
| **Fix** | Fixes element in place |
| **Coincidence** | Coincidence between two elements |
| **Concentricity** | Centre circle around element |
| **Tangency** | Element is tangent to curve/circle/arc |
| **Parallelism** | Two elements become parallel |
| **Perpendicular** | Two elements become perpendicular |
| **Horizontal** | Element is made horizontal |
| **Vertical** | Element is made vertical |

# 3D Tools Used:



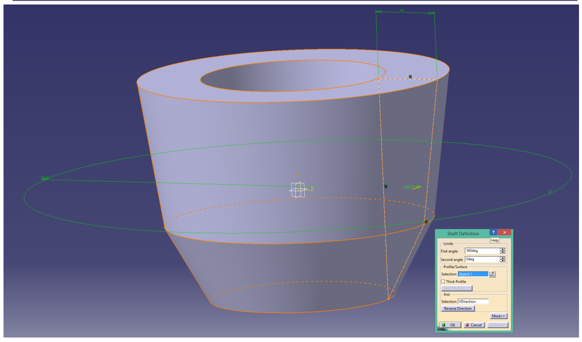

## Pad

This is the simplest 3D tool, in that it simply gives a 2D draft a third dimension. First the pad tool is selected, then the surface, and then you can define the length of the pad. You also have the option of extending it in different direction, or both.



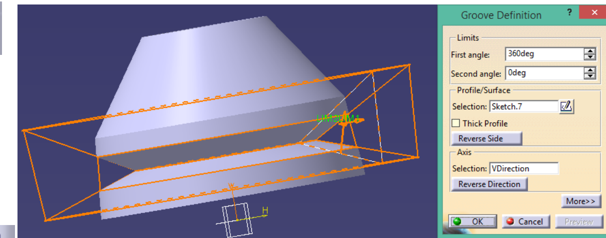

## Pocket

This tool is the opposite of the pad tool, in that instead of adding material, it uses the 2D profile to remove material. This is similar to the hole tool, although it can be used to create a hole with any profile, as opposed to merely a circular one. Similarly to the pad tool, once the tool is selected, you then select the profile and the length.



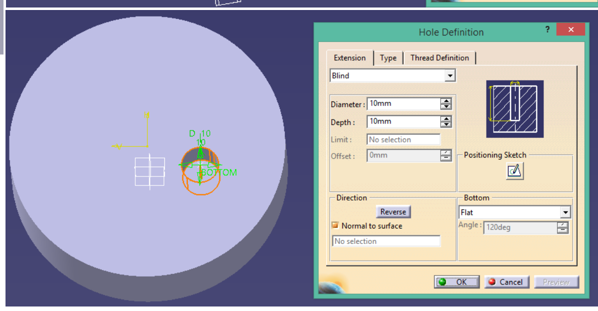
## Shaft

This was one of the most used 3D tools, due to the fact that many of the parts were built to be work around a shaft. To use this tool, you select shaft, then select the profile, and finally the axis it will be built around.




## Groove

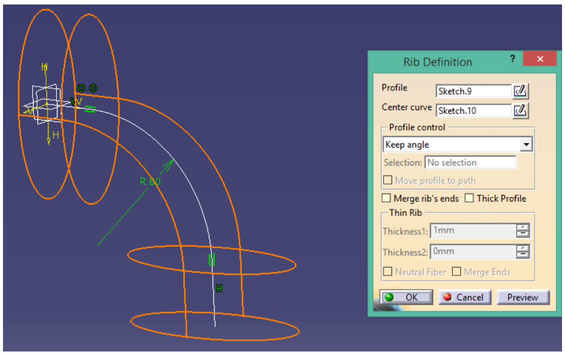
Like the pocket tool, this is the opposite of the shaft, allowing you remove material in a circular motion. You select the tool, then the profile, then the axis.




## Hole

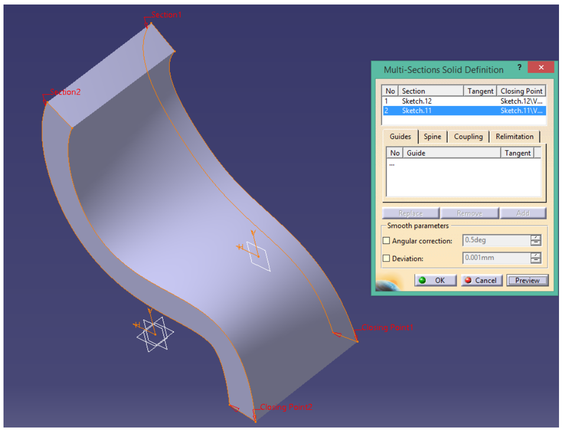
This tool is used to create a hole in a material, with various options to the depth and diameter, including threads. The type of hole can also be adjusted, such as countersunk or counterbore. The hole feature can only do circular holes - any other shape is done using the pocket tool. To position the hole accurately, you can use the position sketch, which allows you to apply constraints between the edges of the part the hole is to be applied to.

## Rib

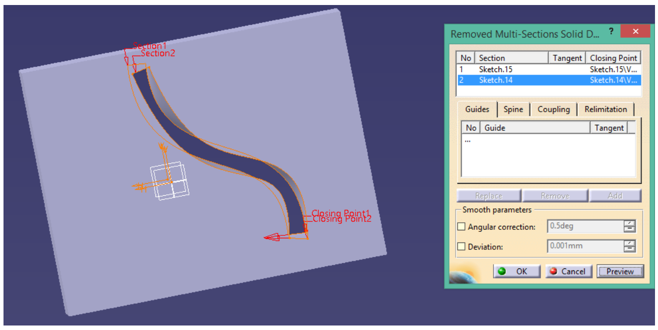

This tool uses two profiles to create a part, one is a profile, while the other is a line or curve etc. that the profile will follow. You can also select the rib to have a hole in the centre by selecting the “Thick Profile” option, which allows profile to be used as a centre for hole to be on. Another way to do this is to add the hole into the initial profile.

## Multi-Sections Solid

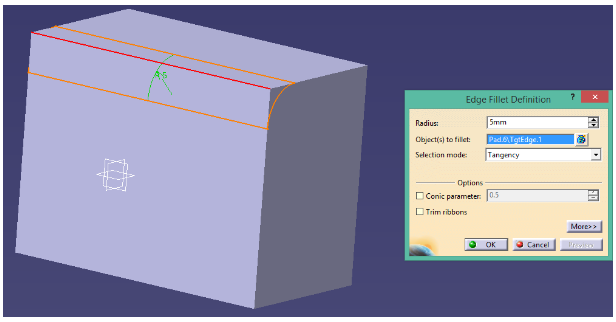

This is one of the most versatile 3D tools used. It allows a part to be built from two profiles on different planes, such as two squares at different angles, which causes a twist. This was used in the model to create the aerofoils on the impeller, by creating a multi-section solid between two spline profiles. When creating a multi-sections solid, you select the tool, then the two (or more if needed) profiles you want to use using MB1 and then select where the closing points are, again with MB1. These two points are the ones that Catia will connect and base the rest of the feature on, so it is important that these two are correct. If Catia doesn’t automatically generate the correct closing points, you must replace them by clicking with MB2 and selecting the “Replace Closing Point” option.

## Removed Multi-Sections Solid

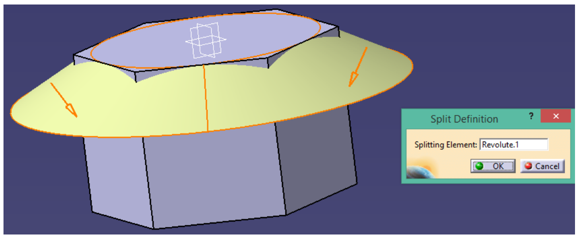

This, similar to the pad and pocket, is the opposite of the multi-sections solid, in that instead of adding material, it, as the name suggest, removes material. It is more advanced than the pocket in that it has two separate profiles, and can create curved or twisted pockets in the material. Like the multi-sections solid it requires two profiles, and two closing points. The method of operation is also identical.

## Edge Fillet



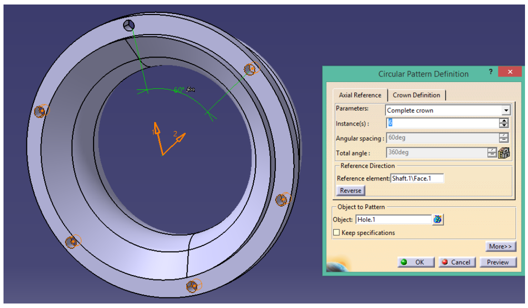

This tool is similar to the corner tool in 2D sketching, however it allows a fillet to be produced between two different 3D elements, e.g. a shaft and a multi-sections solid. To implement an edge fillet, select the tool, then the edge you want to fillet and then designate the radius the fillet is to be drawn with.

## Split



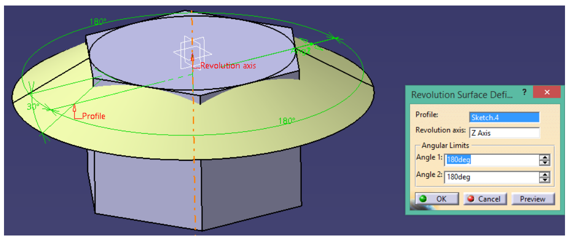

This tool is used to cut one element with another, for example cutting the turbine nut (a hexagon pad) with the revolution surface to create a chamfer. To do this select the split tool by clicking on the down arrow next to the thick edge tool and selecting split, then simply select element to be split, and click on the arrow provided to select the direction of the cut.

## Circular Pattern



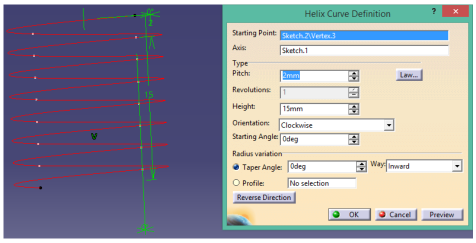

This tool was widely used to repeat holes on parts. To select this tool, click the down arrow next to rectangular patter and select circular pattern. Next, select the parameters, in this model this was always "Complete Crown," then select a reference direction, which in this case was any circular face on the part that used the same axis, then finally selecting the part to be patterned.

## Revolution Surface Definition



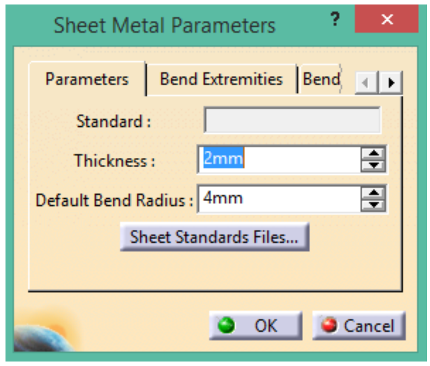

This is a tool from the Generative Shape Design workbench, that was used in conjunction with the split tool to create the circular chamfer on both the turbine nut and adapter parts, although admittedly a groove would have been easier. It uses a profile and revolves it around an axis to create a 2D profile in 3D space (as opposed to for instance a shaft, it has no depth). To select this tool either navigate through Start -> Shape -> Generative Shape Design, or use the power input c: revolute, then select the profile you want to revolute and the axis around to do such.

## Helix




This is a tool from the Generative Shape Design workbench, which allowed me to create a helical shape from one vertical line for the axis and one horizontal line for the starting point. This profile could then be used with the rib tool to create the spring. To start with select the helix tool by either selecting Start -> Shape -> Generative Shape Design, then the down arrow next to the spline tool to select the helix tool, or by using the power input c: helix to use the tool directly. Using MB1 you then select the two profiles you want to use and then define the height and pitch of the helix.

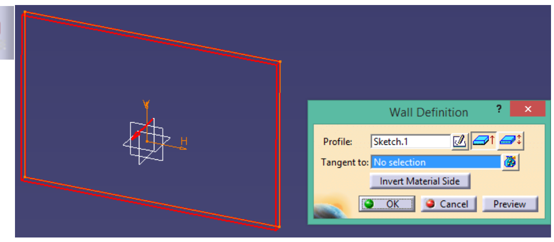
# Generative Sheetmetal Tools Used:




## Sheet Metal Parameters

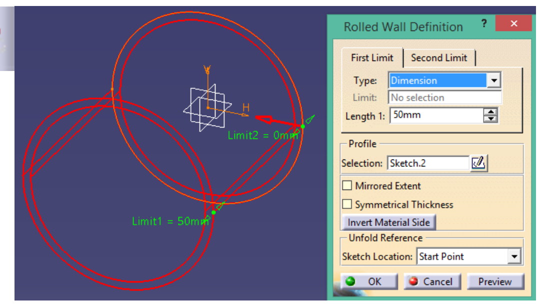
This is one of the major differences between Part Design and Generative Sheet Metal Design. To be able to start working on a part, you must first define the thickness of the metal, as well as what radius it will bend at.

## Wall



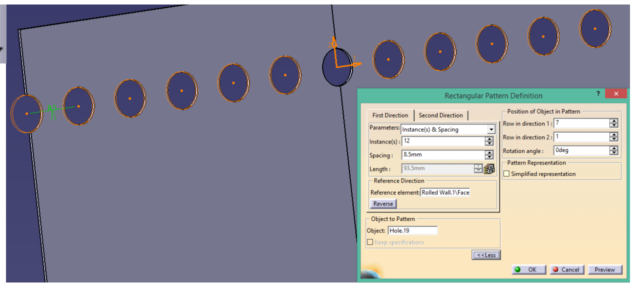

This is similar to the pad tool in Part Design, except that it will only use the thickness of metal you designated in sheet metal parameters. To begin, select the wall tool, then the profile you want used. You also have the option of tangency to a different wall, but this was not used in this model.

## Rolled Wall




This tool was used to create the Inner and Outer Wrapper for the Combustion Chamber. To create a rolled wall, select the tool, then the profile (a circle of x radius/diameter) and the length of the wall. Finally, you can determine on which side of the profile the wall should be created, the inside and/or outside, as well as the unfold reference.

### Rectangular Pattern

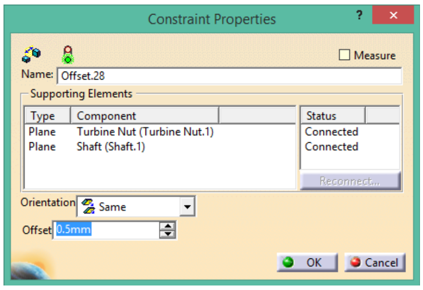
This tool is identical to rectangular pattern available in Part Design, and was used to create the many holes in the Inner and Outer Wrapper. First select the tool, then define the parameters, in our case Instance(s) and Spacing, as this was easiest (the instances and spacing values were given in the drafts), the number of instances, the spacing the reference direction and the object to pattern. Due to the location of the original hole in both the Inner and Outer Wrapper, the "Position of Object in Patter" option under "more" was used, as holes had to patterned both left and right of the original.

## Assembly Tools Used:

### Coincidence Constraint

This is a very simple tool to use, and the majority of the time simply involved selecting the axis of two parts with MB1 to cause them to lie on the same axis. It can also be used on faces, but was not used in this model, as all parts had an axis.

### Offset Constraint

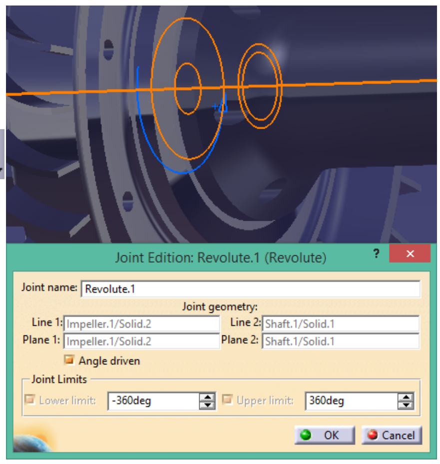




This tool was used to define the position of the objects in the assembly by defining the offset (most often 0) between various objects. To do this, you first select the tool, then the faces that you want the offset to be between, and if needed select the direction of the part.

### Fix

This, as the name suggests, fixes the object in place. This is done by simply selecting the object with MB1, and it is then fixed.

## DMU Kinematics Tools Used:

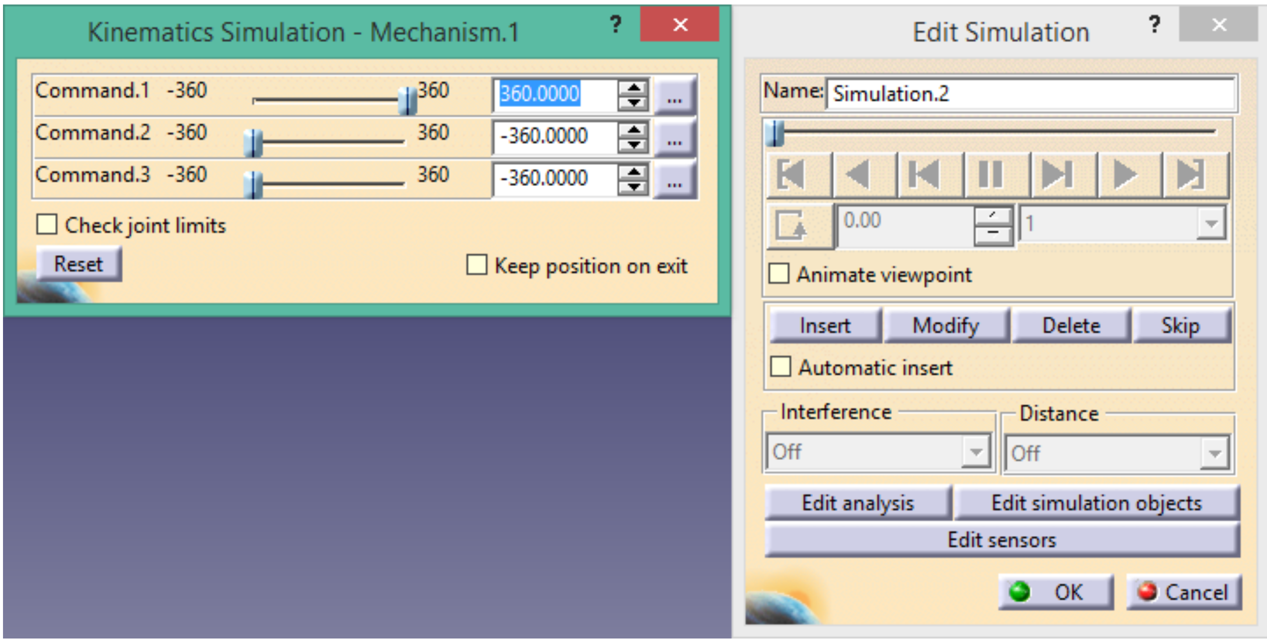




### Revolute Joint

This tool was used to generate the joints to be used in simulation. To do this, select the tool, then the axis and faces of the two parts to be joined, and in the case of this model, select "Angle drive." If it is not already, set the joint limits to -360 -> 360.

### Simulation

This tool is used to animate joints and is extremely difficult to use. To do so, select the tool, and then the mechanism you want to animate. Next use the sliders to define the animation that the part is supposed to display, and click “Insert.” The problems come when parts spin in different direction, but must turn in the same direction as part of the animation. To do this, you must move the slider, insert a motion, delete it, move it in reverse to the original motion and insert it again.



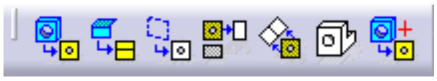

### Fix

This tool was identical to that used in the assembly, and if not already converted from the assembly constraints, could be implemented in the exact same way. It is important for simulations, as at least one part must be fixed for an element to be animated.

## Drafting Tools Used:

### Automatic View Creation Wizard

When you are in part design and then select drafting, the automatic view creation wizard pops up in the bottom right and allows you to pick the views generated. These include a full front, back, top, bottom and side views as well as an isometric view, as well as smaller combinations, such as just front, side and top view.



## Front View

This tool allows you to add a view of a face from part design into drafting, by selecting the face and then placing it into the draft by returning to the draft document and clicking with MB1 at the desired location.

## Isometric View

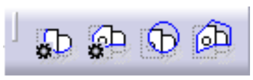
This tool allows a 3D view to be added into the draft, set by the current orientation of the object in part design and finalised by clicking a face, returning to the draft document and clicking with MB1 at the desired location.

## Unfolded View

This view is specifically for the Generative Sheetmetal Design workbench, and allows an object to be unfolded in the draft. This was used to show an unfolded view of the Inner and Outer Combustion Wrappers. To add this view, click on the unfold view tool, then go to the part you want the view from and select it with MB1, then return to the draft document and place by clicking with MB1.

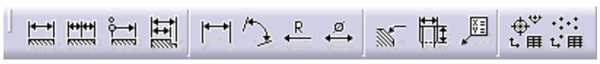
## Section and Cut Views

There were also a number of views that could be produced from the front view, such as section cut, or section view, which allowed the object to be cut along a line to see the interior.



## Detail and Clipping Views

The last set of views used were the detail and clipping views, which came in a variety of formats, allowing zoomed in views of specific areas, particularly useful for parts such as the diffuser to zoom in on the shaft and show the intricate details and show the dimensions without it being cramped.



## Dimensions

In drafting, dimension annotations can be selected by clicking on the tool and then on the edge you want to annotate. To show distances, either select more than one edge beforehand or once you have selected one edge with the dimension tool, click on another one. There are a number of dimensions available, such as length, distance, radius, diameter, chamfer and angle. Other options include cumulative dimensions, or multiple dimensions, as well as thread dimensions. Sketch tools involve specifying particular dimensions, such as the vertical height of a diagonal line.

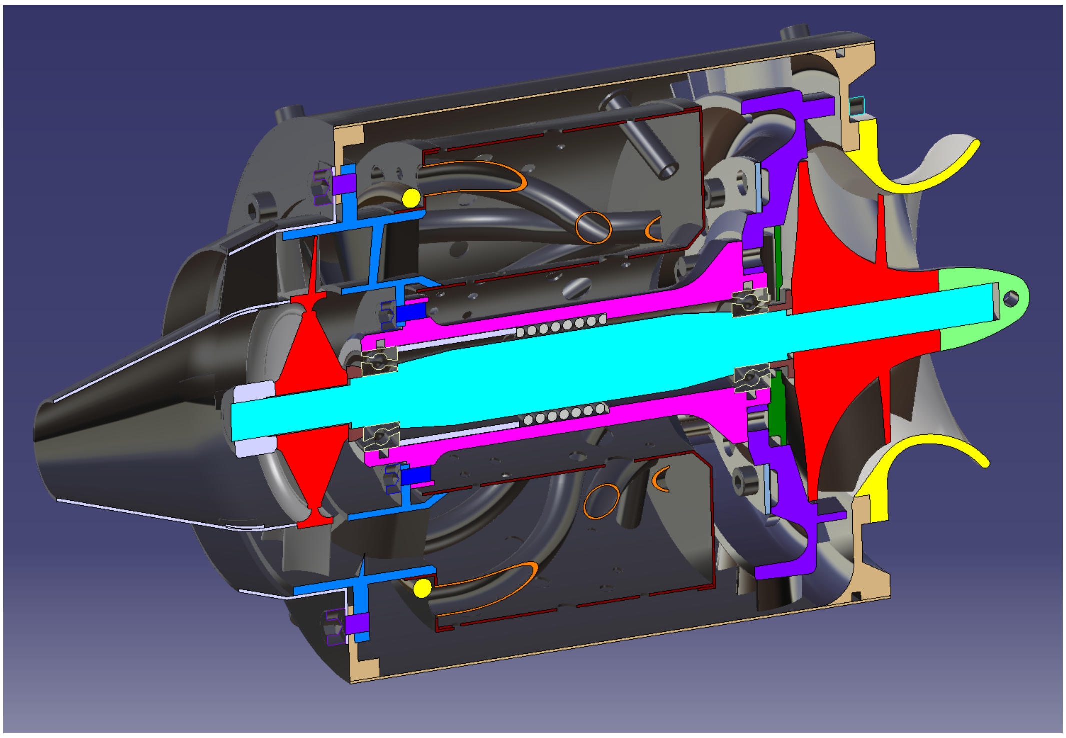
## Annotations

The last drafting tool used was the annotation tool, which was useful for labelling each draft with the part number etc, dimensions that couldn't be shown with the tools given, or annotating other details related to the part. There were three options used; a free standing text box, a table, and a text box connected to an arrow.

## Axis Tools

This allowed the axis lines of holes, shafts, tubes etc. to be displayed and dimensions to be shown between them, or the centre point of a hole or thread.

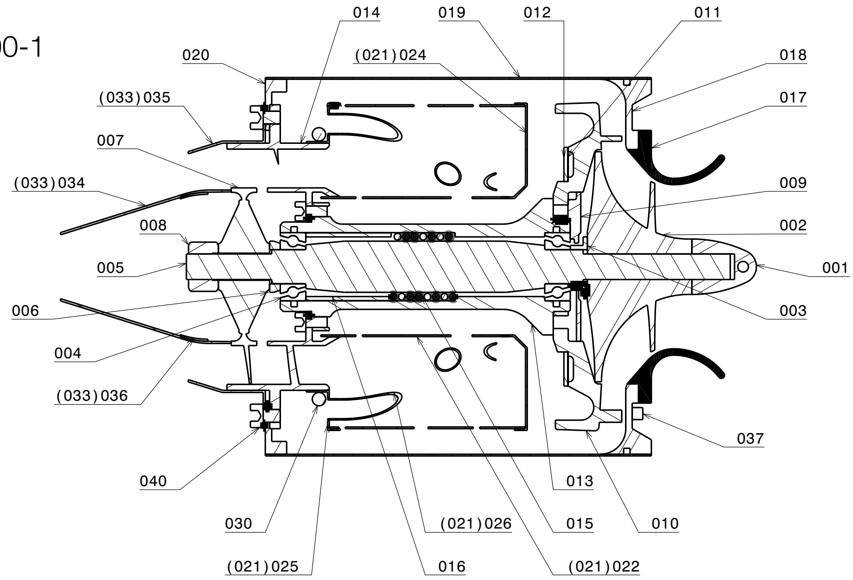
# Part Reports



## 000 Assembly

The assembly was created using the part assembly workbench, and used the coincidence constraint and offset constraint tools to arrange them, as well as the repeat pattern tool to insert the cap screws into the required holes.

Fig. 000-1



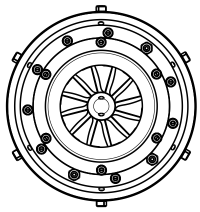



Fig. 000-2

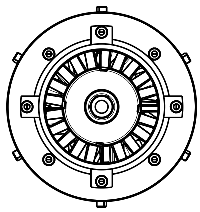


Fig. 000-3

The assembly was redone four or five times, but the first part was always either the nozzle guide vanes or the shaft tunnel, and whichever came first, the other came second. The shaft, bearings, preload tube and spring were then all constrained into their various positions inside the shaft tunnel, and then the two spacers were added at either end. Next, the two rotating parts were added, as well as their respective nuts; the impeller and turbine. After this, the diffuser and shaft seal were added, and the filter and filter cover were added onto the diffuser. Then the combustion chamber assembly was connected to the nozzle guide vanes, as was the rear case and cone assembly. The case outer was the added to the case rear, and the case front was attached to the outer. The intake was added next, to the case front. The case outer was then hidden and the fuel pipe assembly was added. The last parts added were the cap screws, which were constrained to the axis of their holes and then moved in with the compass or offset constraint.

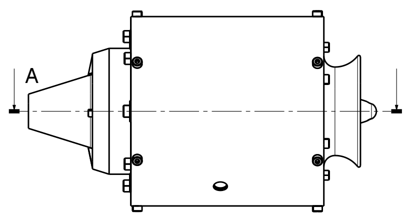


Fig. 000-4

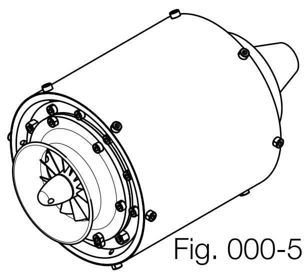


Fig. 000-5

## 001 Compressor Nut

This was a simple drawing that consisted of a profile as can be seen in Fig. 001-1. The shaft tool was then used to create a shaft around the central axis that can be seen in Fig. 001-2 to create main body. Lastly, 2 holes were created, one large one at the bottom for the shaft and another perpendicular to the axis which is for a Tommy bar. One of the issues with this part was the drawing was unclear as to whether the Tommy bar hole went all the way through or only part of the way. Due to the ambiguity the assumption was made that the hole went all the way through, as there was no depth given. The 2D designs were created by using the automatic view creation wizard, and adding a section cut using the central axis A-A to give Fig. 001-2. The final part can be seen in the isometric view in 001-3.

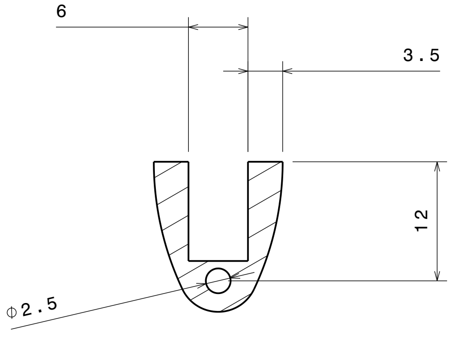



Fig. 001-1

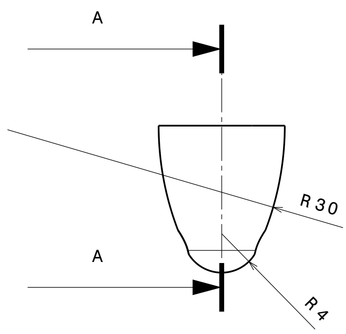



Fig. 001-2

then

Fig.

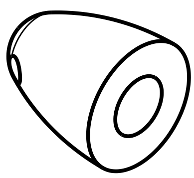


Fig. 001-3

## 002 Impeller

This was by far the hardest part to create, and also took the longest time to determine exactly how to create it. Due to it's aerofoil shape, it required the multi-section solid tool. A few of the original ideas were to use a pad, for instance combining multiple pads together, but the only other method would have been to use the Generative Shape Design workbench and drawn the aerofoil there. Instead, two planes were used, with two different spline profiles to generate the twisting effect. One plane was the original one positioned at start, the other was offset 27mm from it. The central profile was rectangular, very tall and thin, while the outer profile resembled an S shape. Due to the impeller part being made by Garrett (for turbochargers) rather than Wren Turbines, there were no dimensions available for the aerofoil, although they were available for the shaft and groove (see Appendix III). Originally, dimensions of the impeller used with the Wren 70 engine available in college were used, until it was discovered that it was actually a different compressor. The impeller used in the original MW54 plans is a Garrett 446335-9 compressor wheel, but since then it is onto it's 3rd update, the Mk3, and has a new one, in a similar style to the Wren 70, but a smaller height, the 445347-18. In the end, the model used was taken from the 3DS Max design by Alan Wheeler, while the dimensions were estimated. The multi-section solid can be seen in Fig. 002-2. The rest of the design was relatively basic as it only required a profile to be shafted for the inner cone like shape and a groove to remove the C shaped cut in the aerofoil. This groove fits perfectly with the intake part. The last detail is a .5mm fillet either side of where the aerofoil connects to the central shaft, and can be easily seen in the isometric view in Fig. 002-4.

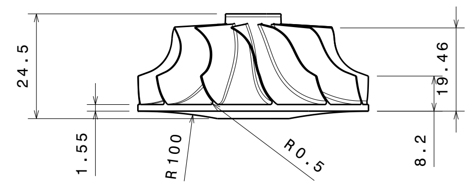


Fig. 002-1

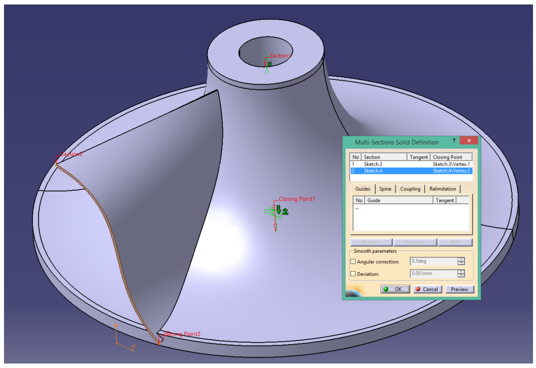


Fig. 002-2

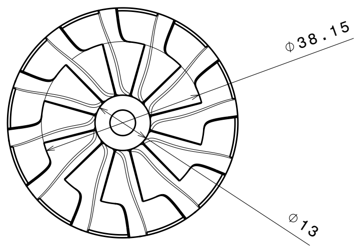


Fig. 002-3

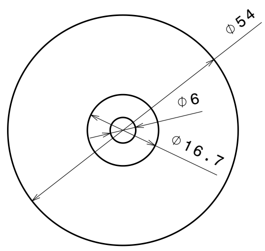


Fig. 002-4

The 2D drawings were done using the automatic view creation wizard. Due to the nature of the groove and multi-sections solid, a sketch of the aerofoil section was not possible.

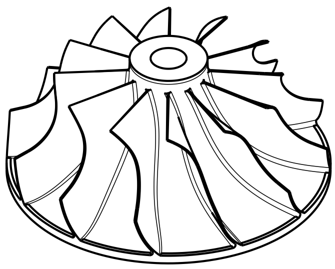


Fig. 002-5

## 003 Front Spacer

This part took a maximum of two minutes to complete as it is simply a few lines drawn as a profile for a shaft, as can be seen in Fig. 003-1+2. The 2D drawings were done using the automatic view creation wizard. The final result can be seen in the isometric view in Fig. 003-3.

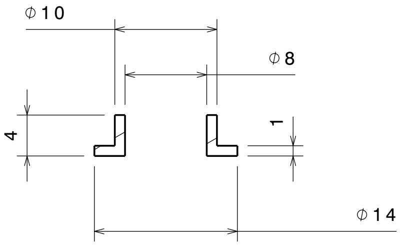



Fig. 003-1

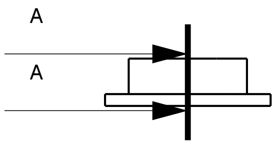



Fig. 003-2

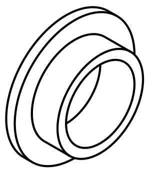


Fig. 003-3

## 004 688/602 Bearing

This was a very simple part in the sense that the original plan was to simply create cylinder profile and pad it to the correct length. Later on, this was replaced with a model from an external source, due to it being a standard bearing, which featured a far more detailed model including the ball bearings and rims rather than just using their overall shape. The original part was created in part design, while the downloaded .CATPart file was done in the generative shape design workbench, and most likely was converted from a separate CAD program, such as SolidWorks.

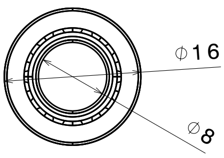



Fig. 004-1

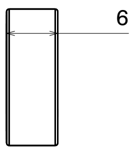



Fig. 004-2

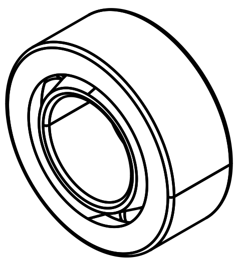


Fig. 004-3

## 005 Shaft

This was the first part to be designed, partly because it was early on in the plans, seemingly simple to draw and was a major part in the model. It was done using the shaft tool with a profile for the entire length of the shaft around a central axis. Another option could have been to use the pad and chamfer tool, but the shaft tool was the most logical solution. The dimensions used can be seen in Fig. 005-1. The 2D Drafts were done using the automatic view creation wizard. The final view can be seen in Fig. 005-2.

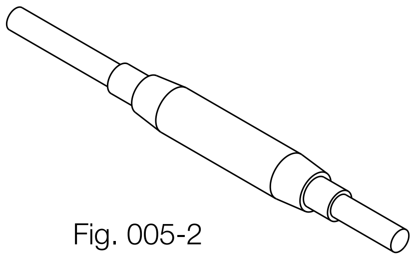


Fig. 005-2

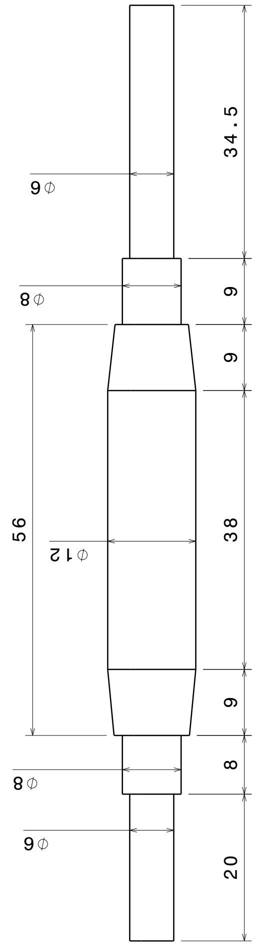


Fig. 005-1

## 006 Rear Spacer

Similarly to the front spacer, the rear spacer is simply a shafted profile, which can be seen in Fig. 006-1. The result can be seen in Fig. 006-2+3. The 2D drawings were done using the view creation wizard.

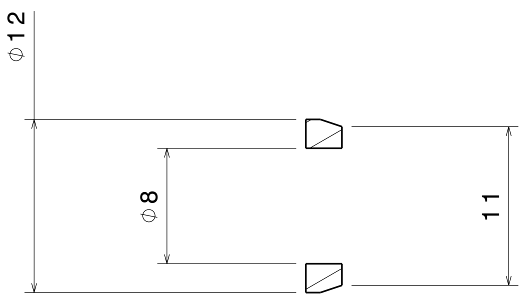


Fig. 006-1

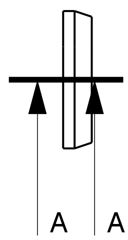


Fig. 006-2

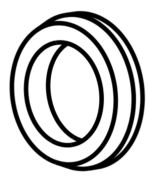


Fig. 006-3

## 007 Turbine

Due to the aerofoil shaped turbine blades on this part, it seemed a rather daunting task but turned out surprisingly easy. Due to the nature of the aerofoil blades and their position to the central shaft, this part required a shaft, as can be seen in Fig. 007-1, an offset plane positioned at the edge of it and a further one at the required length of the blade, connected using a multi-sections solid, as can be seen in Fig. 007-4.

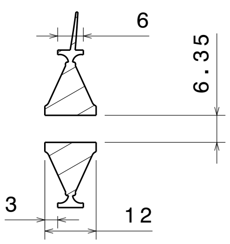


Fig. 007-1

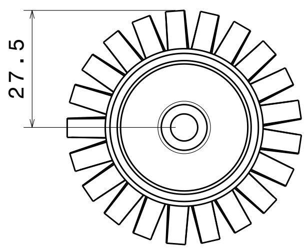


Fig. 007-2

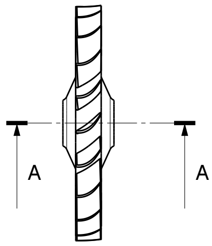


Fig. 007-3

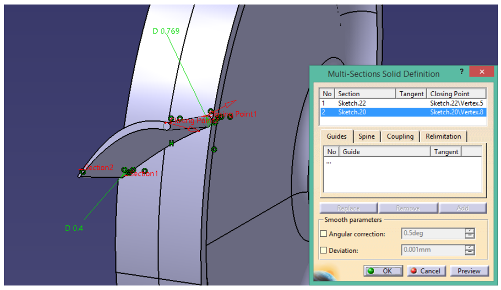


Fig. 007-4

## 008 Turbine Nut

Despite the seeming simple design, this part used one of the most advanced tools so far, from the Generative Shape Design workbench; the revolute tool. This allows a 2D profile to be made into 3 dimensions, as despite having no length, it has coordinates in all three. This was used coupled with the split tool to create the chamfered edge at the top and bottom of the nut. The rest of the part was simple, as it only required a padded hexagon shape with a counterbored hole in the centre. The 2D designs were done using the automatic view creation wizard, along with a section cut along the central axis. The final view can be seen in Fig. 008-4.

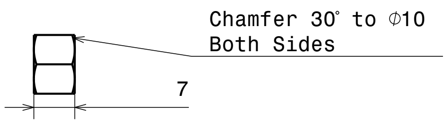


Fig. 008-1

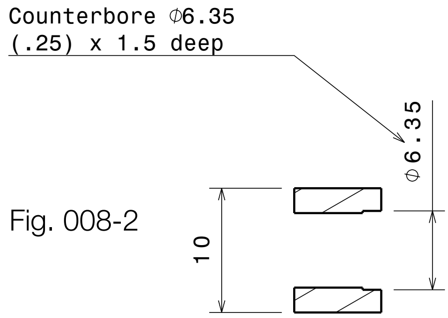


Fig. 008-2

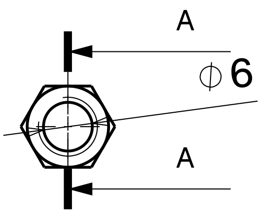


Fig. 008-3

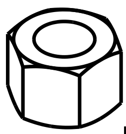


Fig. 008-4

## 009 Shaft Seal

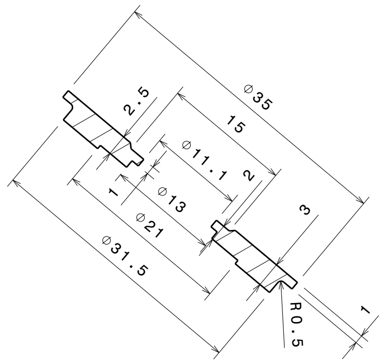


Fig. 009-1

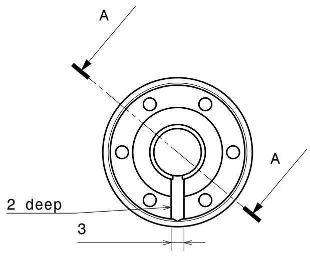


Fig. 009-2

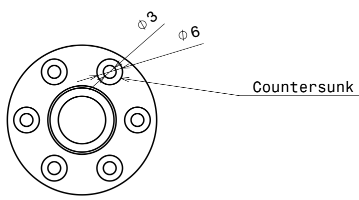


Fig. 009-3

This was a rather simple part but caused a few small problems, due to the countersunk holes seen in Fig. 009-3 and the groove that can be seen in Fig. 009-2. The shaft itself was relatively simple, but the groove caused a problem due to the fact that it was in the shape of a semicircle and yet it was 3 across and 2 deep. This issue was that the radius of the circle was not given, and a standard semicircle of 3mm diameter would have been 1.5 mm deep. This meant that the pocket tool had to be used, which hadn't been done before, but was done fairly easily. After this, the issue was the countersunk holes. These were done using the hole tool, which makes it rather easy. However, it was not discovered until the assembly that the holes were actually done wrong, as they did not fit the countersunk cap screws that they were made for. It turns out that when you input the values of the countersink that the angle Catia asks for is not the one given in most drawings. In this case for example, the holes were countersunk by 45°. To put this into Catia however, you have to put in 90°, as it measured the angle between the lines, not the angle between the line and the axis of the whole like is given in the plans. This was easily rectified by editing the hole and updating the component, whereby the assembly automatically updated. The final product can be seen in the isometric view in Fig. 009-4. The 2D drafts were done using the automatic view creation wizard, along with a section cut view to create Fig. 009-1.

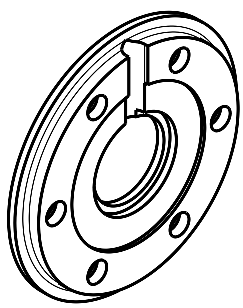


Fig. 009-4

## 010 Diffuser

This was one of the most difficult parts to create, due to the complexity of the shaft, as well as the pads for the wedges and the aerofoil profiles along the outside and lastly the positioning of the wedges and the holes. The shaft required quite a while to build, due to the large amount of angled lines and chamfers, various radii and tangents, as can bee seen in Fig. 010-1+2. The difficulty was in getting all the constraints to work together properly and not have the object be overconstrained. By the time it was finished however, it looked good, and the detailed constraints allowed the two pads to be added easier. Despite the worry that the wedges would be difficult to create, they turned out to be ridiculously easy, as the drafts provided the perfect details for the constraints, as can be seen in Fig. 010-3. This meant that the pad was created and could be slid around the diameter of the shaft with MB1, allowing positioning to be rather easy. Once this was done, a technique identical to that used on the turbine blades was implemented to create the aerofoil pads on the outside, the design for these seen in Fig. 010-6. The next issue was the placement of the holes. This was also relatively simple, and merely required the holes to be centred on the vertical axis, and the correct circular patterns to be used. As can be seen in Fig. 010-4 at the right side of the view, starting with the hole labelled ⌀3mm. Incidentally there were 2 additional holes like this, built for the fuel, lubrication and gas pipes. The final view can be seen in Fig. 010-7. The 2D views were created using the automatic view creation wizard, as well as section cut and detail cut views.

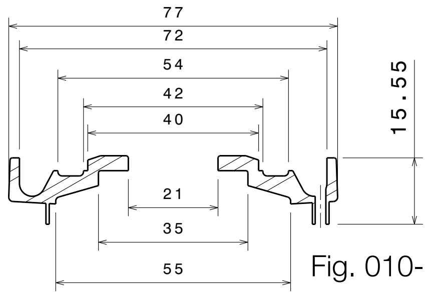



Fig. 010-1

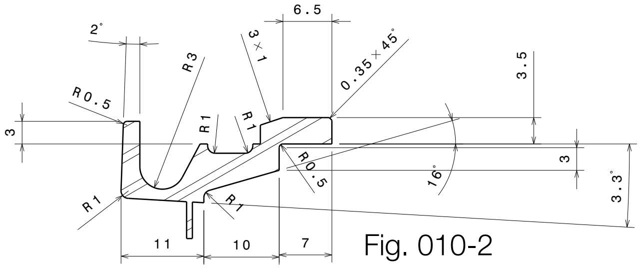



Fig. 010-2

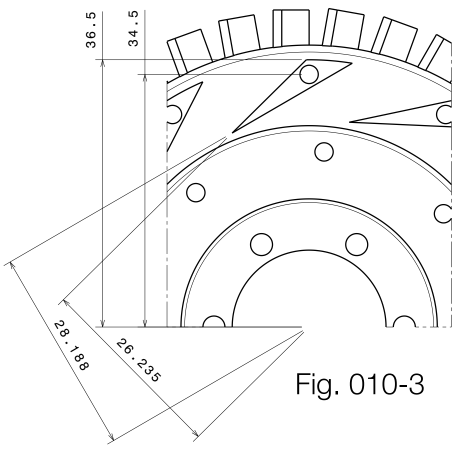



Fig. 010-3

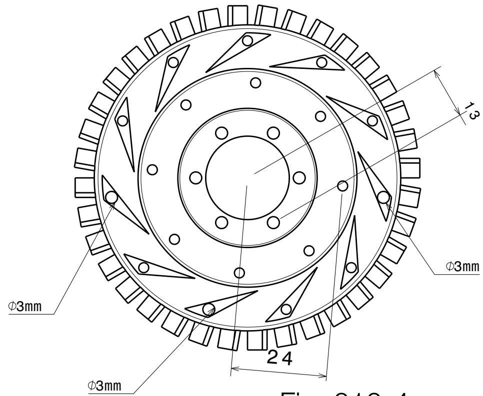



Fig. 010-4

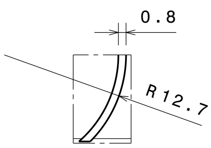



Fig. 010-5

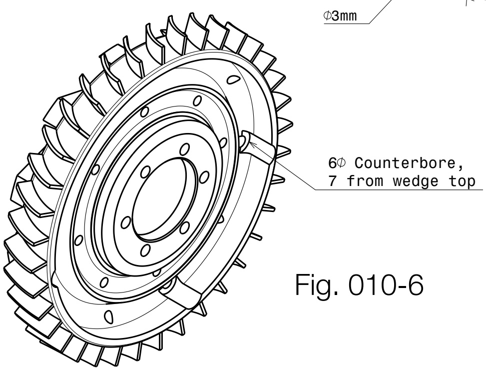



Fig. 010-6

## 011 Filter

This was one of the later drawings done, and was very easy to do. It was simply to circles to create the profile for a pad, then the holes were added on the correct diameter line.

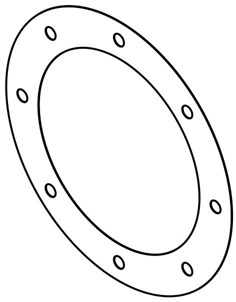


Fig. 011-3

Fig. 011-1

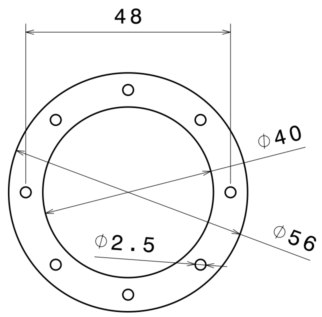



Fig. 011-2


## 012 Filter Cover

The filter cover used the exact same theory as the filter, the only difference being the thickness of the material. Also the were another set of holes superimposed on top of the first set, along circular patterns to be used on both occasions, while still allowing for the two sets of hole sizes.

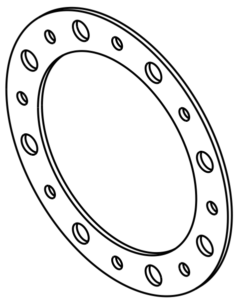


Fig. 012-3

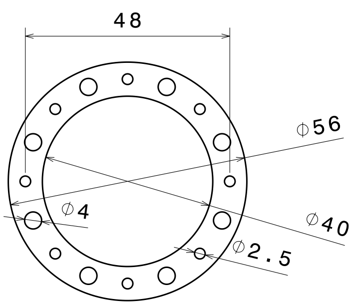



Fig. 012-1

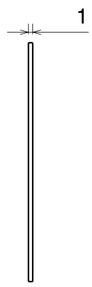



Fig. 012-2

## 013 Shaft Tunnel

This was another of the earlier parts that was designed, as it was also relatively simple to do, although it also had to be redone later due to differences in the Wren 70 and MW54 engines. One issue with this part was that it became easier to remove some of the constraints to make the drawing clearer, however, this lead to some lines to be changed without it being realised, causing their lengths (in this case) to be too short.

To build this part, there were a number of tools used in the drafting, the main one being the line tool, as well as the circle. The main constraint was the length, as well as radius, and for the curved section to the left of the axis (see Fig. 013-1) tangency was used. Lastly, a chamfer tool was implemented at either end of the drawing to create the two chamfers. One this sketch was complete, the shaft generated using the shaft tool around the axis seen in the centre of Fig. 013-1, to create the shaft tunnel.

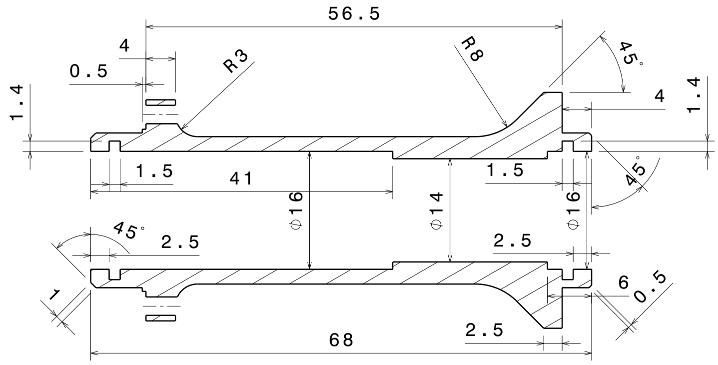


Fig. 013-1

The holes on shaft were left till later, as there were issues with placing them correctly. When Catia places a hole, it merely takes where you clicked on the surface as the input, so it took until the knowledge to place them accurately was available for the holes to be added. The only known method at that point was to select an edge and then a surface, such as padded circle, in which case it will position the hole in the concentrically. This was not applicable for the shaft, although it turned out to be rather simple - one just has to use the "Project 3D Elements" tool or select the edge in the positioning sketch and then set constraints to set the holes in the correct place. The holes can be seen in Figs. 013-2+3.

Originally the measurements in the plans were used, which were often threaded, but due to a known limitation of Catia, t can only thread holes and not pads, such as a cap screw, so the two parts (e.g Shaft Tunnel and M2.5x5 cap screw) clashed. To avoid this the diameter of the holes (2.5mm) was used instead of the thread (M2.5). The final shaft can be seen in Fig. 013-4.

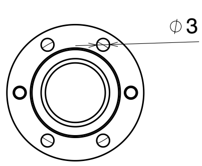


Fig. 013-2

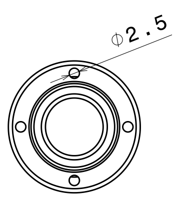


Fig. 013-3

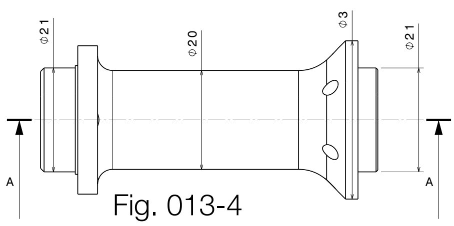


Fig. 013-4

## 014 Nozzle Guide Vanes

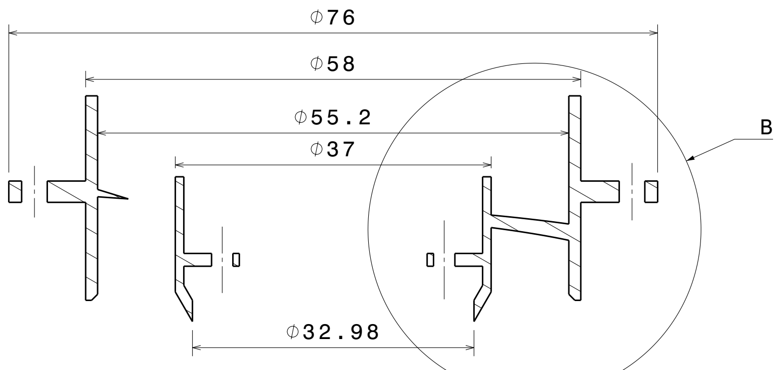



Fig. 014-1

This was a particularly annoying part, and possibly should have been made up of three parts instead of the one (e.g how the cone was done). This was due to the parts constantly moving incorrectly when constraints were applied. This was particularly the case between the NGV inner and outer, but also the NGV inner and the axis. Another issue was the two 30˚ parallel lines on the inner NGV, which were constantly changing despite a constraints being applied. The profile created to form the shaft can be seen clearly in Fig. 014-2. The next issue was the aerofoil that needed to be padded in-between the two parts. This was done by using a plane offset from the original onto the inner part of the outer NGV. The pad was curved around the inner shaft, the aerofoil pad had to clash with the outer shafts so there were no gaps, which required a bit of shuffling. The aerofoil can be seen in Fig. 014-3. The rest of the views were created using the automatic view creation wizard, as well as a section cut and a detailed cut to show the shaft and aerofoil profiles. The final view can be see in in Fig. 014-6.

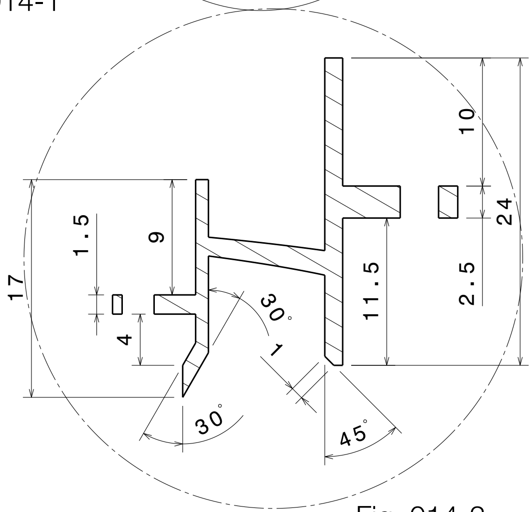



Fig. 014-2

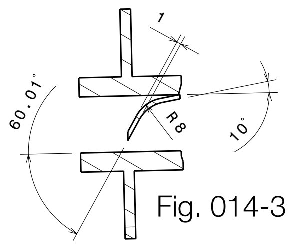



Fig. 014-3

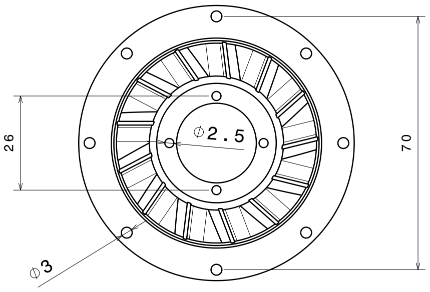



Fig. 014-4

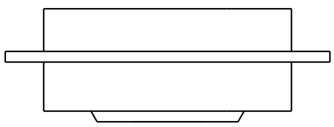


Fig. 014-5

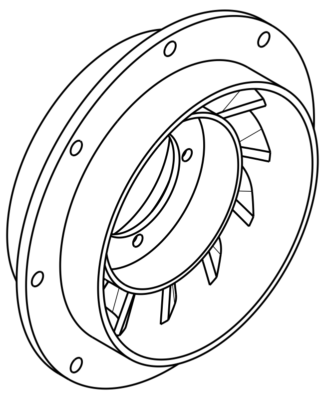


Fig. 014-6

## 015 Spring

This part required one of the more advanced features of Catia, the helix tool in the generative shape design workbench. To create this, a horizontal and vertical line were used to create the helix curve as seen in Fig. 015-3, which was then made into the spring using the rib tool and a circular profile, then selecting the helix curve as the central curve for the rib. The 2D drafts were created using the automatic view creation wizard. The final part can be seen in Fig. 015-4.

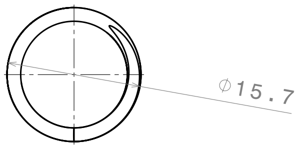



Fig. 015-1

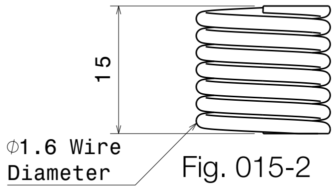



Fig. 015-2

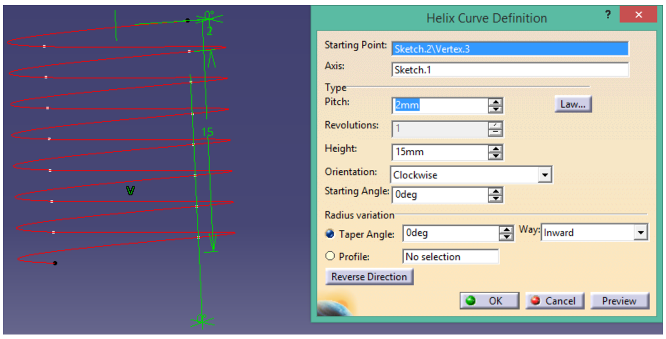



Fig. 015-3

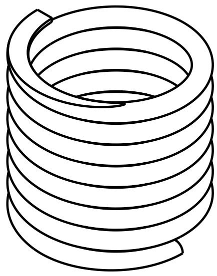


Fig. 015-4

## 016 Preload Tube

This was an extremely simple part that was made up of a profile of two circles padded to the correct dimensions. The 2D drafts were created using the automatic view creation wizard, and the final part can be seen in Fig. 016-3.

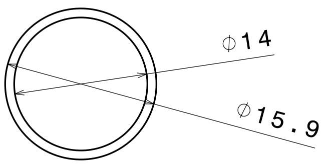



Fig. 016-1

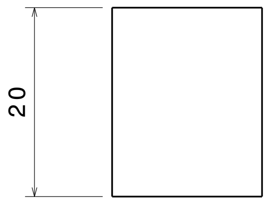



Fig. 016-2

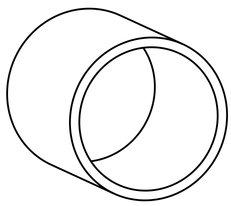


Fig. 016-3

## 017 Intake

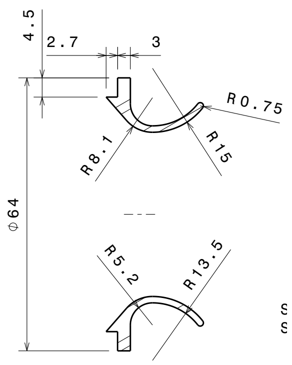


Fig. 017-1

This is one of the earliest drawings done, and when it was first approached, seemed like an extremely daunting task. It also had to be redone at a later date due to mistakes that were made that initially went unnoticed. It is actually one of the easiest drawings, considering it is one of the major parts of the assembly. This drawing required the use of the following tools: shaft, hole and circular pattern.

To begin with, use Fig. 017-1 to draw the shaft. It is important that the sketch is the required distance from the axis; this is where the initial mistake was made which meant that the intake diameter was less than it should have been; this was noticed during the assembly when it clashed with the impeller. When the shaft is complete, the result should be a part similar to Fig. 017-2. If the distance from the axis (19.25mm) is incorrect, then the shaft will either be too large or too small. It is easiest to start from the 3mm line furthest from the axis to start. From there the lines are relatively simple, and using the circle and trim tools makes the curves easier. The last curve (R8.1) is then trimmed to the diagonal line using the tangency constraint.

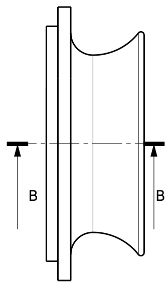


Fig. 017-2

Once this is complete, move onto the holes, set on a distance of 30mm from the centre (see Fig. 017-3). This is done using a position sketch and a 2 mm distance constraint from the outer line of the shaft and being on the centre line to make position in the assembly easier.

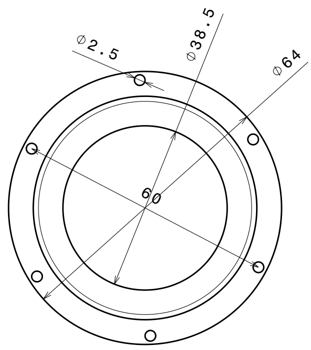


Fig. 017-3

The final result can be seen in the isometric drawing Fig. 017-4.

The 2D drafts are done with the automatic view creation tool and a section cut was added along axis B-B.

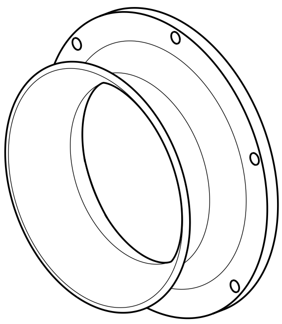


Fig. 017-14

## 018 Case Front

The case front is one of the most important parts in the assembly as it connects three different parts together; the intake, the diffuser and the case outer. It is made up of a shaft profile, as can be seen in Fig. 018-1+2. It was relatively simple to draw, and the shaft tool was then used to create the shape seen in Fig. 018-3. The holes were all orientated around the horizontal axis and then a circular pattern was added for each hole to provide the correct number of instances. The 2D drafts were done using the automatic view creation wizard and the section cut tool. The final view can seen in Fig. 018-4.

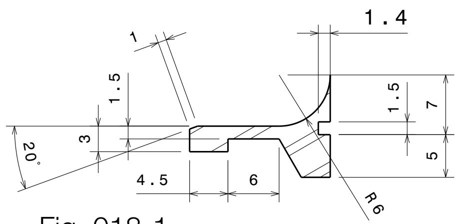


Fig. 018-1

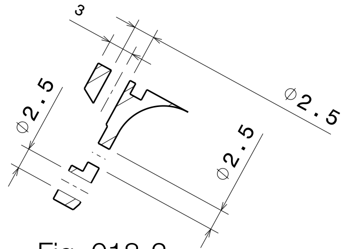


Fig. 018-2

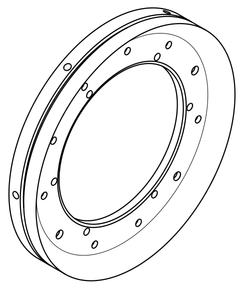


Fig. 018-4

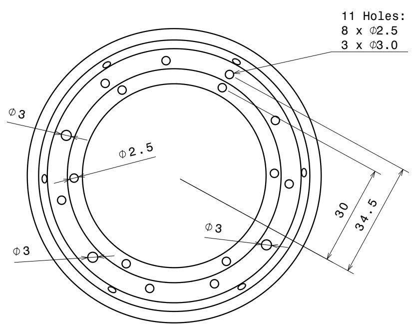


Fig. 018-3

## 019 Case Outer

The case outer originally done in part design, but this was replaced with another model done in generative sheetmetal design. This allowed easier position of the holes, especially the ones for the glow plug boss. To do this, the rolled wall tool was used, and when the part was viewed in the unfolded view, the holes were added, with the required rectangular patters. The 2D drafts were done using the automatic view creation wizard and the unfolded view.

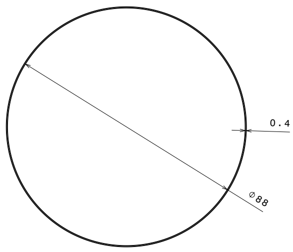


Fig. 019-1

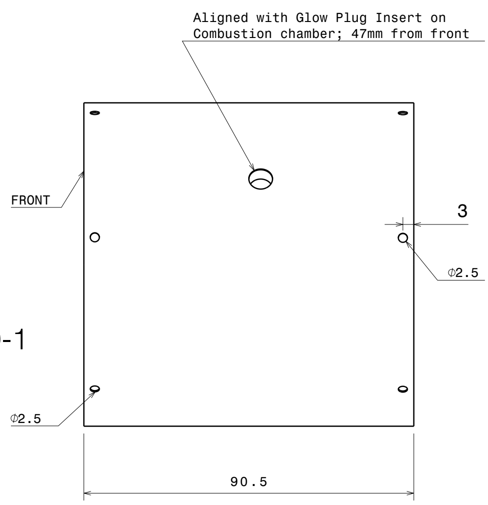


Fig. 019-1

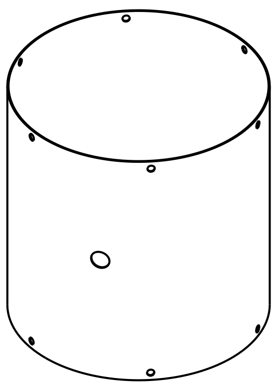


Fig. 019-1

## 020 Case Rear

The case rear is very similar to the case font, and was done around the same time. It consists of a profile, as can be seen in Fig. 020-1, which is made into a shaft using the shaft tool, and two sets of holes. The final part can be seen using the isometric view Fig. 020-4. The 2D drafts were created using the automatic view creation wizard, as well as a section cut to show the shaft profile.

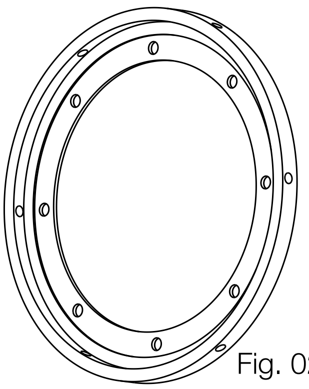


Fig. 020-4

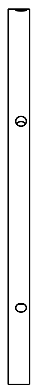


Fig. 020-3

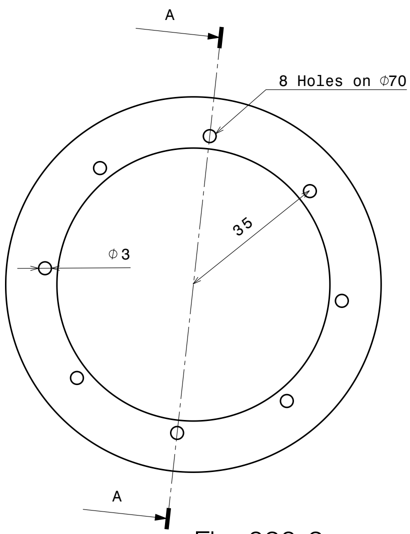



Fig. 020-2

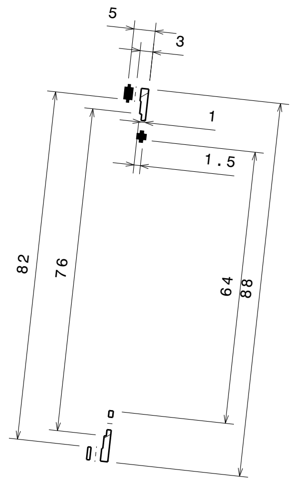



Fig. 020-1

## 021 Combustion Chamber Assembly

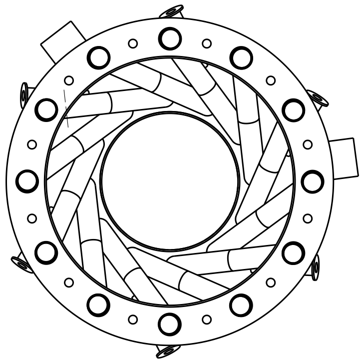


Fig. 021-1

The combustion chamber was made out of the following parts: the inner and outer wrappers, the glow plug bosses, swirl jets, vapouriser tubes and the combustor front and rear. To begin with the inner and outer wrappers and the combustor front and rear were added and put onto the same axis using the coincidence constraint tool. They were then arranged using the offset constrain tool. The inner and out wrappers were fitted onto the combustor front, and then the combustor rear was fitted onto the outer wrapper. A way of distinguishing the front and rear is that the front is the mostly solid part, while the rear has holes in it. Next, the swirl jets were added. Due to the way they were supposed to be arranged, it was not possible to use any constraints, they were simply moved in using the compass. The same thing was done with the vapouriser jets, however a constraint was able to be applied at the top where they connected with the combustor rear. Both parts then made use of the reuse pattern tool to duplicate them using the circular pattern used in the outer wrapper for the swirl jets and the combustor rear for the vapouriser tubes. Lastly the glow plug bosses were added, whose axis were aligned with the two holes in the outer wrapper, but again had to be moved into place using the compass because the contact restraint didn't work properly. Fig. 021-1-3 show the front, rear and side respectively, while 021-3 shows the isometric view. The 2D drafts were created exclusively with the automatic view creation wizard.

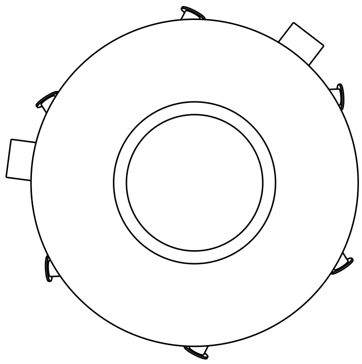


Fig. 021-2

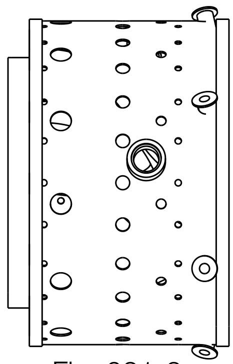


Fig. 021-3

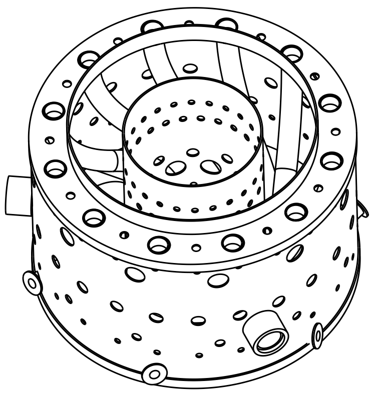


Fig. 021-3

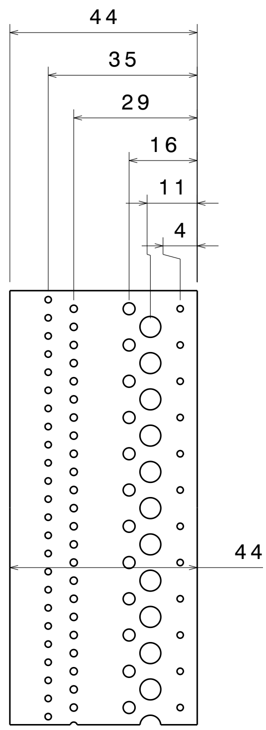


Fig. 022-1

## 022 Inner Combustor Wrapper

This part was originally done in part design, using two circles and a pad to create the cylinder, then using a plane set at an offset from the origin, and then another at the same distance but at a different angle to make sure the holes were perpendicular to the surface and at the correct distance from the other holes. When this part was moved into 2D drafting, it was discovered that the unfolded view only worked for parts designed in generative sheetmetal design, and thus would have to be redone.

However, this turned out to be relatively simple, once the tools needed had been learned. This included the rolled wall tool, the unfold tool and the rectangular pattern tool. Due to nature of the sheetmetal workbench, circular patterns didn't work; the holes and patterns had to be done in the unfolded view. If this was not done, the user was immediately prompted to switch to the correct view or not be able to use the tool. It wasn't hard to use the tool either way because the drafts provided the correct spacing between holes in the unwrapped view as the plans are made for someone to build the engine, and as such are made for a person putting holes on an unfolded sheet and folding it into a circular shape.

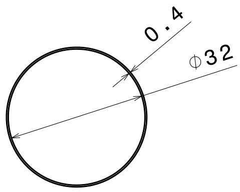


Fig. 022-2

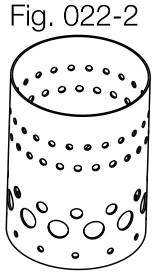


Fig. 022-3

## 023 Outer Combustor Wrapper

The outer wrapper uses the exact same principle as the inner wrapper, just with a larger circumference, and was also redone at the same time as the inner wrapper. The only difference was that the outer wrapper required two extra holes for the glow plug boss and the arrangement was slightly more complicated. The 2D drafts for both parts were created using automatic view creation wizard as well as an unfolded view.

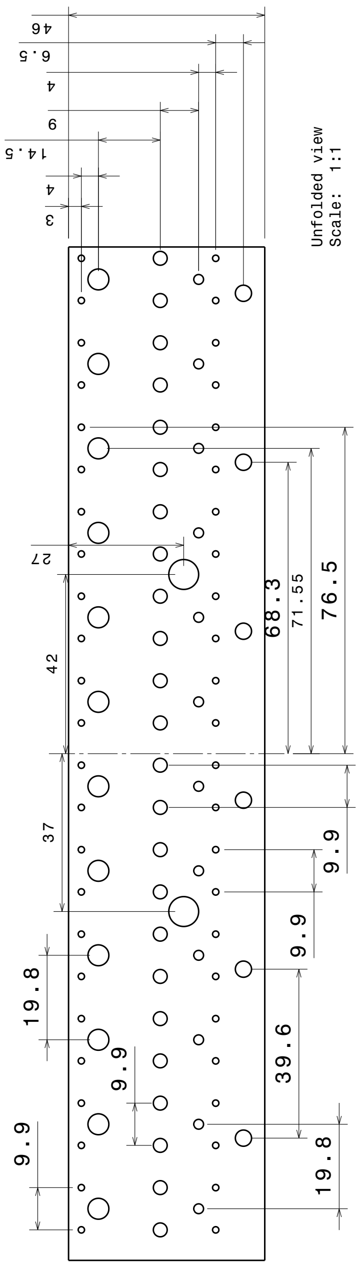


Fig. 023-1

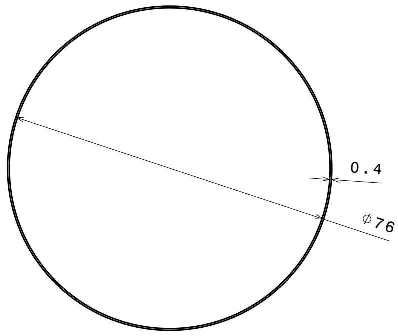


Fig. 023-2

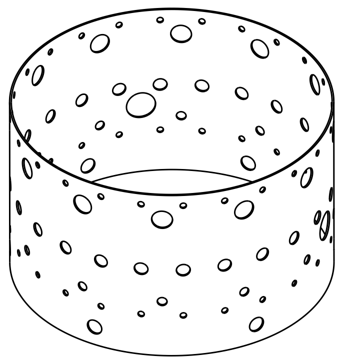
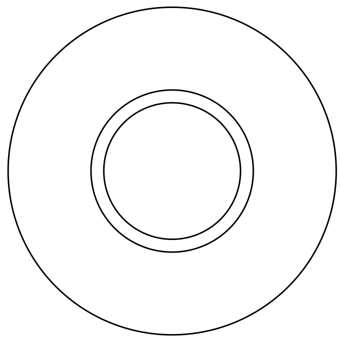
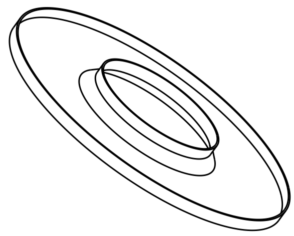


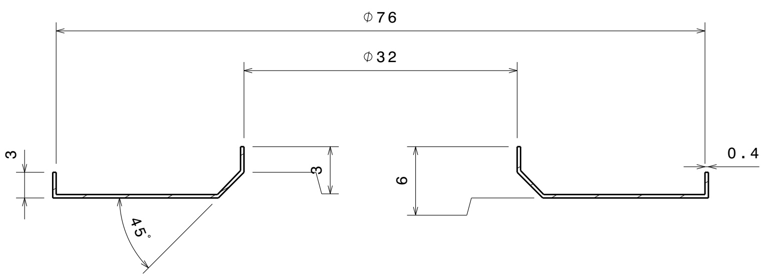
Fig. 023-3

## 024 Combustion Chamber Front

This part was made in part design, however due to it being a sheetmetal part, it could have been made in sheet metal to go with the other combustion chamber parts, however, it was not justifiable due to there not being a need for an unfolded view like the two wrappers. The design was done by creating a profile and the using the shaft tool to create a shaft. The profile can be seen in the section cut Fig. 024-2. The 2D drafts were done using the automatic view creation wizard, as well as the section cut view for the shaft profile.








## 025 Combustion Chamber Rear

The combustor rear is very similar to the combustor front, although it is slightly more complex due to the two hole patterns required. Like the front, the rear is created by using the shaft tool on a profile. Once this was done, one set of holes were added, then the second, larger, set was superimposed on the top. The profile can be seen in the section cut Fig. 025-2. The 2D drafts were done using the automatic view creation wizard, as well as the section cut view for the shaft profile.

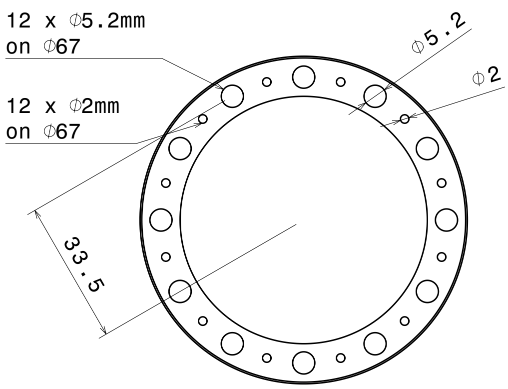



Fig. 025-1

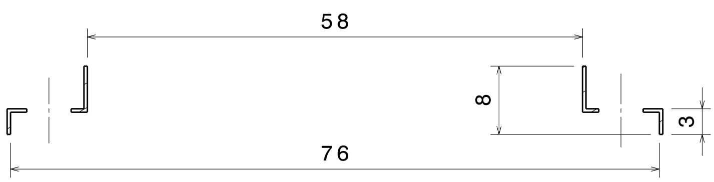



Fig. 025-2

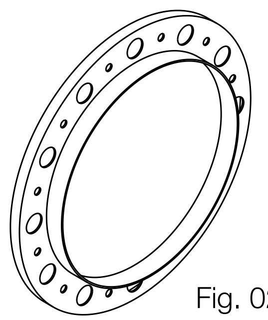


Fig. 025-3

## 026 Vapouriser Tube

This part was made using a circular profile and a line, and then using the rib tool to create the tube. For some reason it was not possible to use the axis tool to display the radius of the central curve which is R25, only the outer radii of the tubing could be shown.

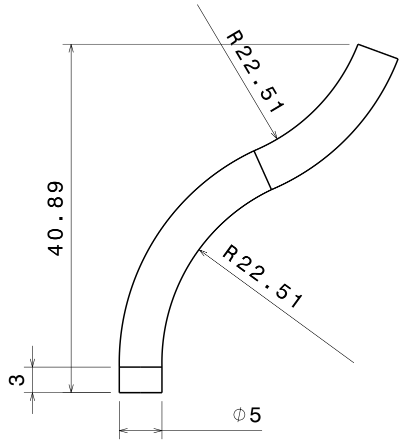



Fig. 026-1

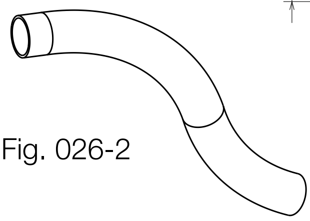


Fig. 026-2

## 027 Swirl Jet

This part was simply two circular pads, one on either side of the vertical plane. It was made very quickly, the only issues being positioning it in the assembly. The 2D drafts were created with the front view tool (see Appendix II), section tool and isometric tool.

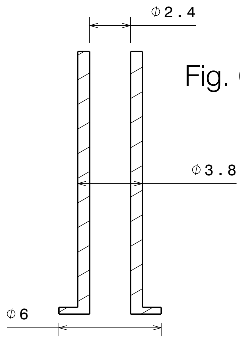



Fig. 027-1

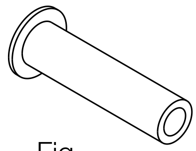


Fig.

## 028 Glow Plug Boss

The glow plug boss was created in the same way as the swirl jet; with two pads on either side of the vertical plane. Here, the issue was that the drafts didn't supply a diameter for the hole, as it was dependent on the spark plug, so it had to be estimated. The 2D drafts were created with the automatic view creation wizard. The final product can be seen in Fig. 028-3.

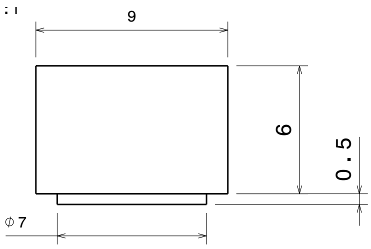



Fig. 028-1

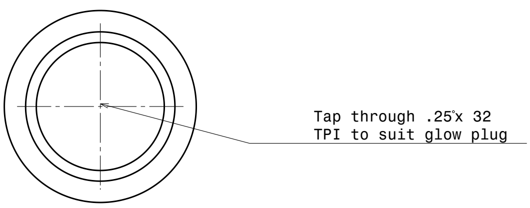



Fig. 028-2

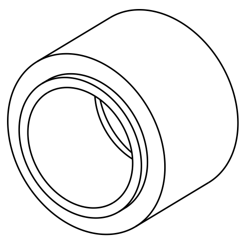


Fig. 028-3

## 029 Fuel Pipe Assembly

The fuel pipe assembly consists of the following parts: the fuel pipe itself, the tube end fitting and the adapter. The fuel pipe fits onto the rim of the combustor rear. From there the pipe passes along the side of the combustion chamber, until it end just before the 3mm counterbored fuel hole in the diffuser. This is where the tube end fitting sits, and is connected to the adapter which sits on the case front, holding it securely in place.

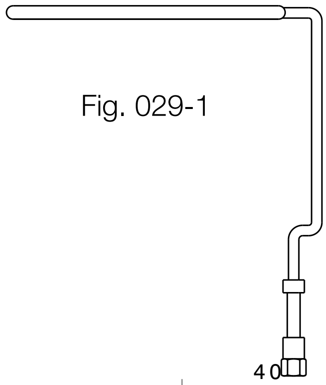


Fig. 029-1

## 030 Fuel Pipe

The fuel pipe was created using a series of ribs, using a circular profile for the tubing and another for the circular fuel pipe, then a long line profile for the rest of the design, with another circular profile for its tubing. The 2D drafts were created with the automatic view creation wizard.

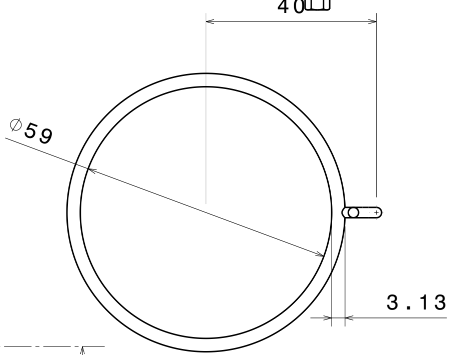


Fig. 030-1

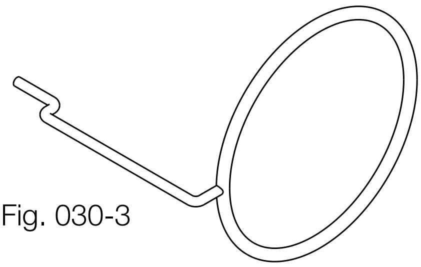


Fig. 030-3

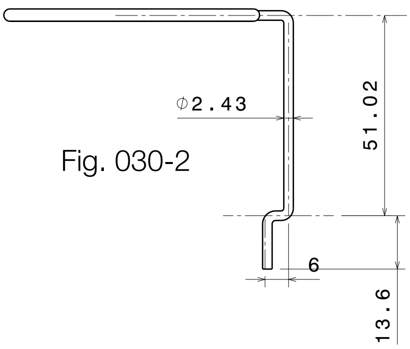
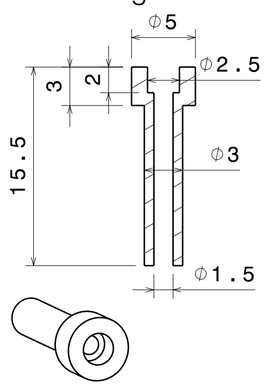


Fig. 030-2

## 031 Tube End Fitting

This was a simple product that only required a profile to be shafted, rather than a pad with a counterbored hole in it, which was the other possible method. The 2D drafts were created with the automatic view creation wizard.

Fig. 031-1



## 032 Adaptor

This was a more advanced part that require the same technique as the turbine nut, and required the revolute and split tools to chamfer the edge. The rest was done using two pads on either side of the vertical plane. The 2D drafts were created with the automatic view creation wizard.

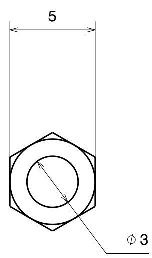


Fig. 032-1

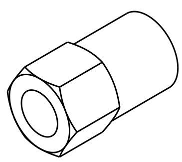


Fig. 032-3

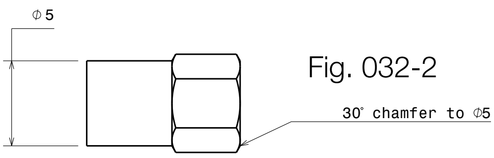


Fig. 032-2

## 033 Cone Assembly

The cone was made out of the following parts: the inner and outer cone and the outlet vanes. The inner and outer cone both had the same axis, and were assembled first, using the coincidence constraint tool, and the offset tool, as seen in Fig. 033-2. Next one outlet vane was added, which was 13mm from the base of the outer cone, or 5 mm from the base from the inner. One thing that wasn't realised at first, and was thought to be an error in the measurements of the outlet vane, was that rather than being merely spot welded onto the two faces facing each other between the inner and outer cone, the outlet vane actually passes through slits on both the inner and outer cone and is welded onto the outside of the outer cone and the inside of the inner cone. In Fig. 033-2 you can just see the flap on the inside of the inner cone and it is clearly notable on the outside of the outer cone in the isometric Fig. 033-3.

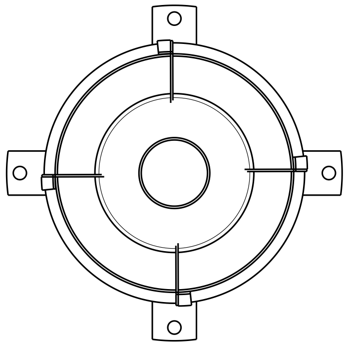


Fig. 033-1

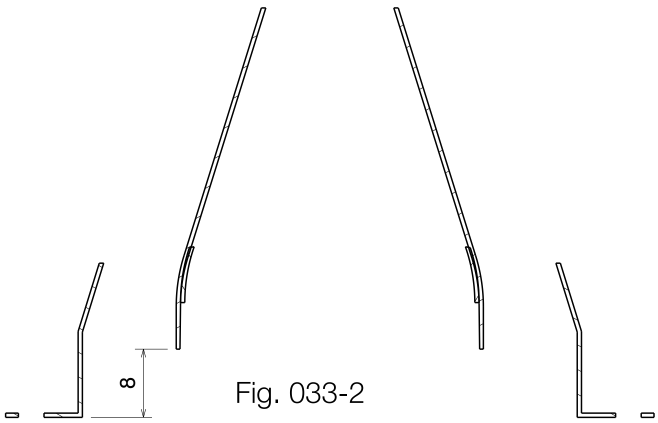



Fig. 033-2

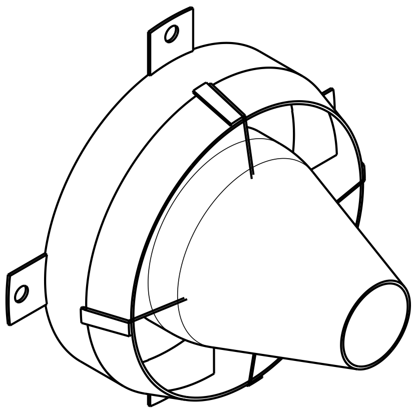


Fig. 033-3

## 034 Inner Cone

The inner cone was created using a shafted profile, as can be seen in Fig. 034-1. Using the shaft tool, the shaft was created, as can be seen in the final view Fig. 034-1. The 2D drafts were created using the automatic view creation tool, as well as a section cut to produce Fig. 034-1.

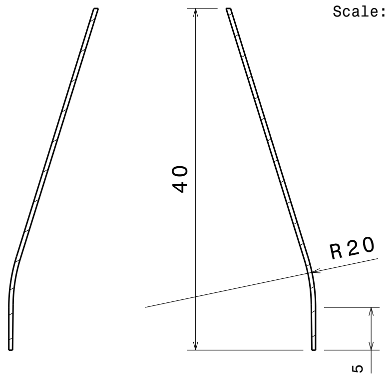



Fig.

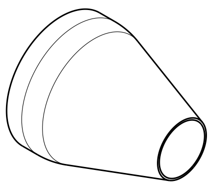


Fig. 034-3

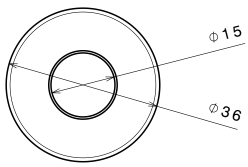



Fig. 034-2

## 035 Outer Cone

The theory for completing the outer cone was identical to the inner cone, other than the 4 pads which had to be created. This was done using the pad tool, and the circular pattern tool, using the projection tool and the arc tool to obtain the curved edges.  The 2D drafts were created using the automatic view creation tool, as well as a section cut to produce Fig. 035-1.

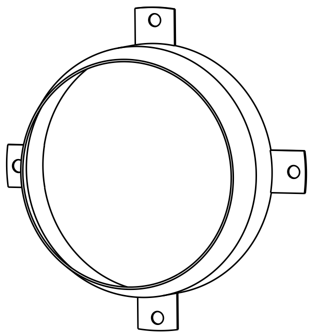


Fig. 035-2

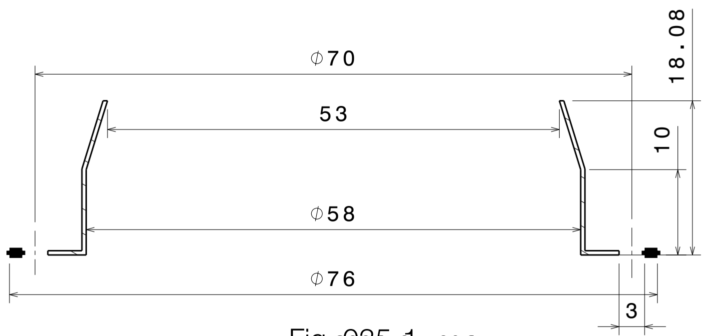
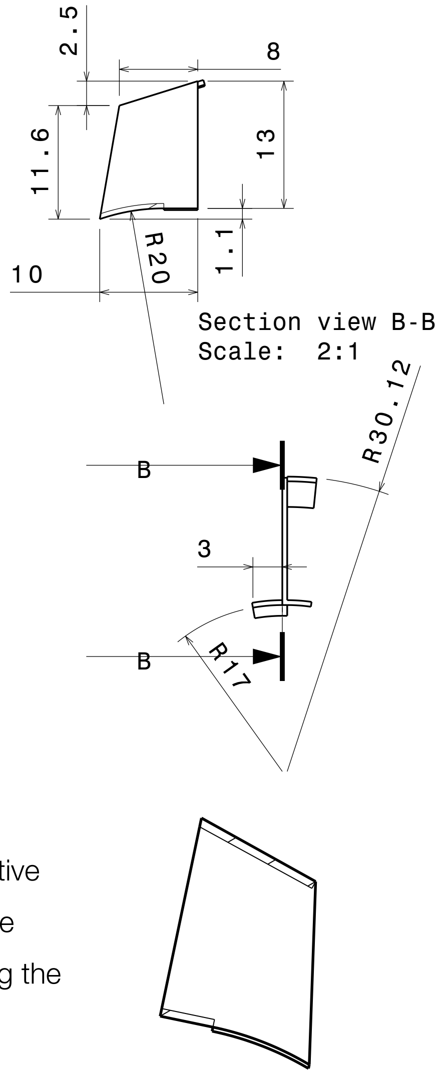
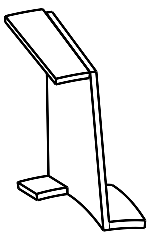



Fig. 035-1

## 036 Outlet Vanes

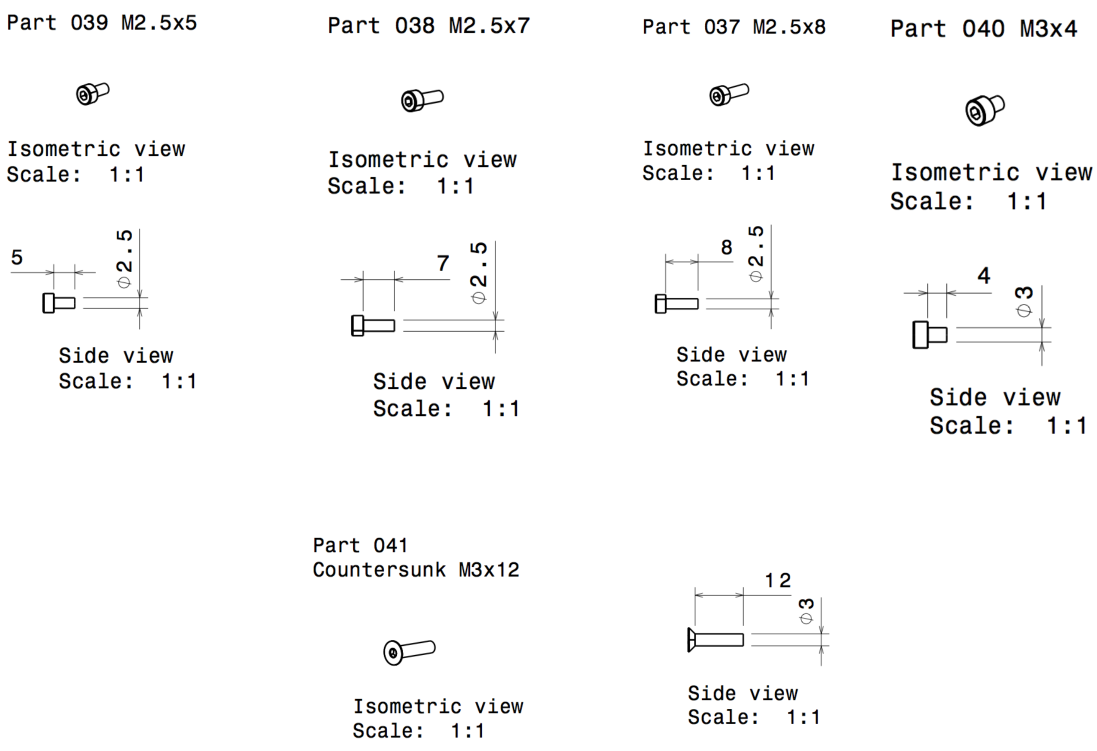



This was the part that, despite it’s simplicity, caused the most problems. This was due to drawbacks within Catia, which caused it to be redone a few times. This was also the last part done, and attempts were made to do it in sheetmetal design, however, it refused to work as there was no way to create a shape with more than one curve in it, or have a rolled wall at a tangent to diagonal edge, the list of ideas that failed was pretty long. After numerous attempts, both in part design and generative sheetmetal design, the end result was virtually the same, and had the same dimensions but lacked the curved edges it should have had. This part would have been possible to create in generative shape design, but that was not possible to learn within the time frame.The final part was made up of a pads and a series of ribs, starting with the main upright one, followed by the two ribs on the left hand side, created by a drawing on the left face of upright pad, followed by the part that caused the most problems in sheet metal, the twofold curved rib on the right. An attempt was made to fillet these, and then add in a multi-section solid to have the effect of a bend from generative sheet metal design, but it fell through. The 2D drafts were created with the automatic view creation wizard. The two side on views were created using the section view tool. The final product can be seen in the isometric view Fig. 036-4.



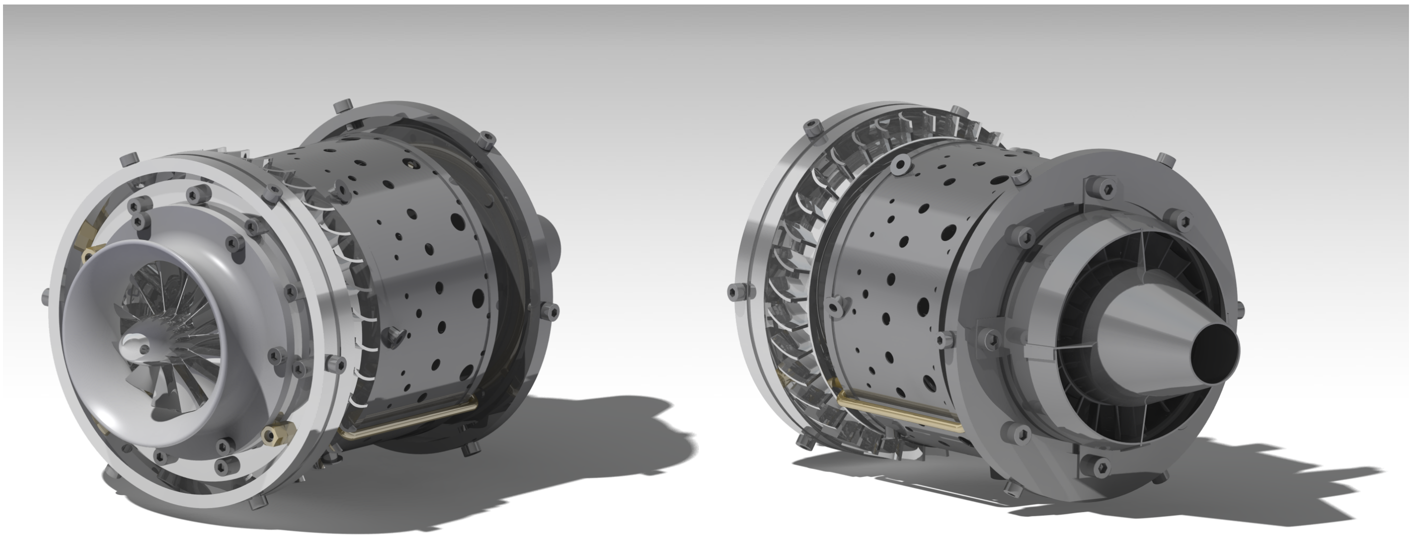
## 037 Cap Screws

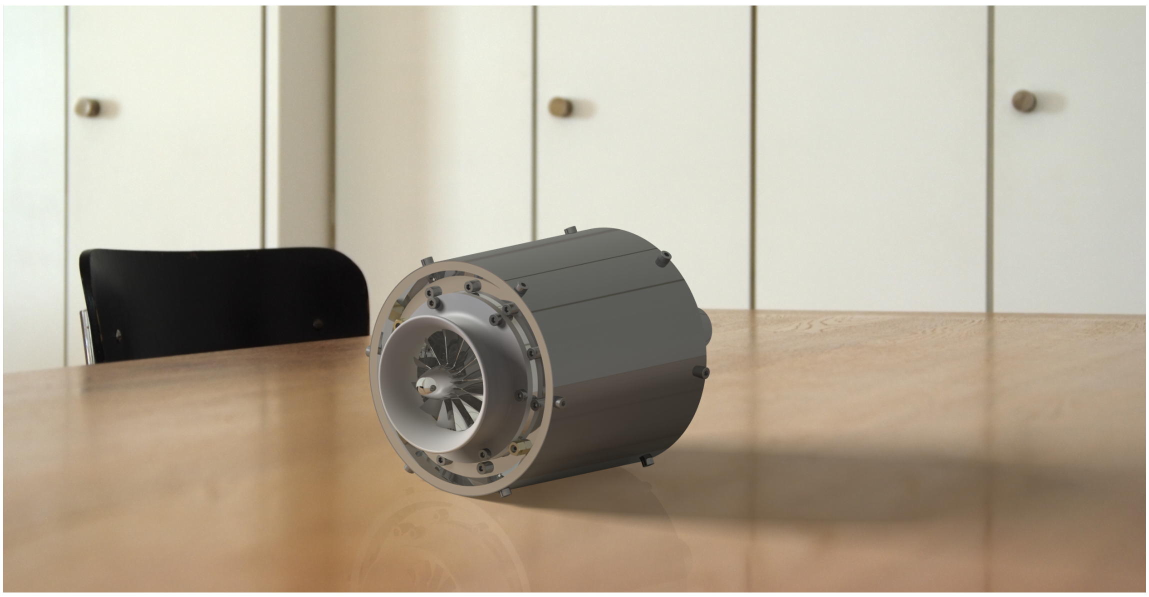
These were a late addition to the assembly as they were originally not going to be done at all, then simply with a hex pad, and eventually like the bearing using an external source that had created the cap screw in generative shape design. These were useless in the beginning as parts from generative shape design do not have a shaft and so were unable to be aligned to the holes. Also, it would have meant downloading each individual screw separately. Instead, the screw part of the cap screw was removed so only the head remained, and the screw was replaced with a circular pad from part design, which had an axis, and meant that the length could be easily edited. Overall there are 52 screws used in the assembly, of which the most is the M2.5x5, of which there are 22. The 2D drafts were done using the isometric view and the front view.



# Conclusion

Overall, this project has been a resounding success. The 3D model is complete, accurate, and is a good representation for people wishing to see what they will end up with if they attempt to build the MW54. It has already gained popularity on the CAD file sharing website GrabCAD and recognition from employees at Wren Turbine, which is a good indicator of it's success. The 2D drafts produced from the model are also to a high standard, and it should be possible for anyone to use a 3D design program to replicate the drawings themselves, or use them in building the product itself. In terms of reaching a high level of competence in Catia v5, this was accomplished to a degree, in the sense that only certain workbenches were explored, while others still need to be learned, in particular the generative shape design workbench.





# Evaluation

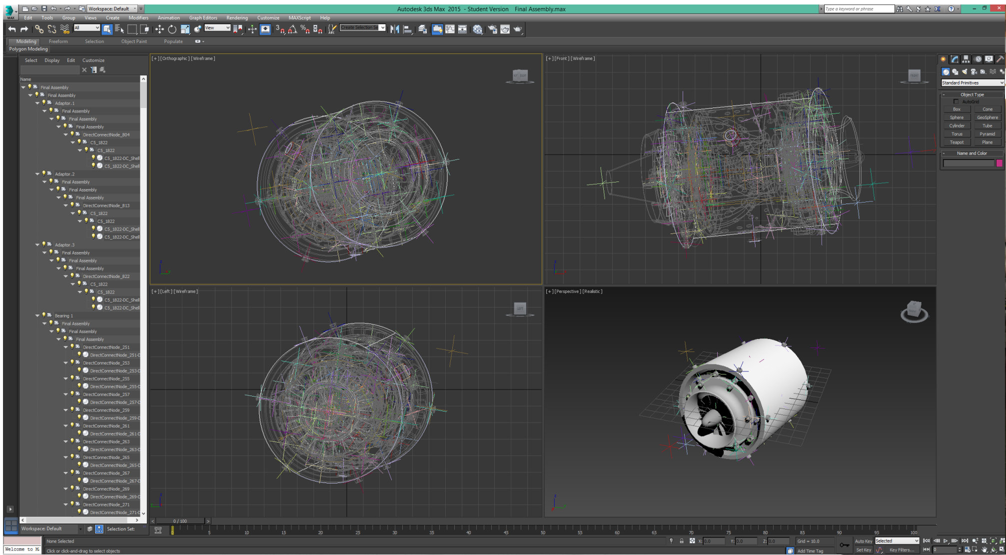
Looking back on this project, I'm extremely glad I chose to do this particular one. By picking to model the Wren Turbine I have gained valuable experience using Catia v5 and received recognition and praise from a number of sources, through it being uploaded to the GrabCAD database, where jt has just reached 60 downloads, as well as comments from various users including a 3DS branch, from Wren Turbine themselves, who I have been in email contact with, as well as friends and family. These two were only possible because I opted to change my model from the Wren 70 to doing the older MW54, which is no longer in production. I'm extremely proud of my work, and am looking forward to doing more.

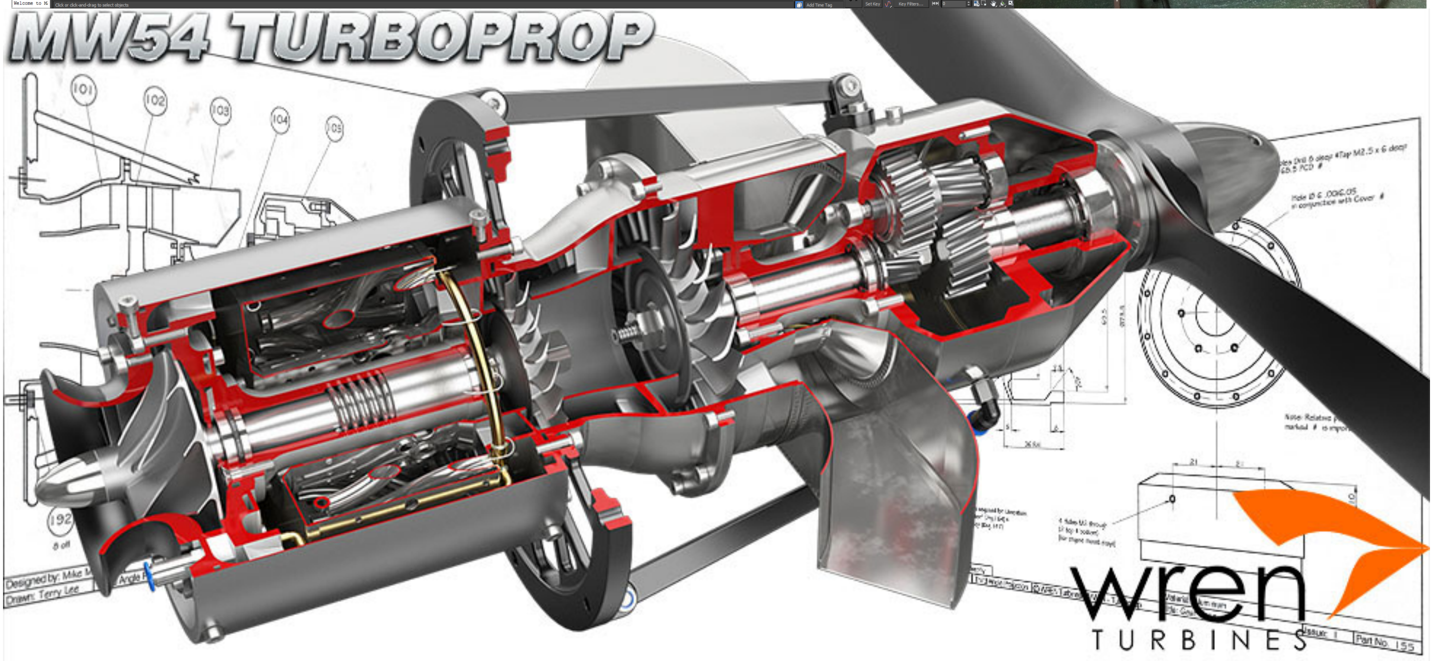
Looking at my original plan I realise it was unrealistic, but at the time I didn't realise just how long it would take for me to become accustomed to Catia, as well as time management during the period of November to January to handle workload from other subjects as well as the Graded Unit.

One of the main things I've discovered over the past few months of using Catia is that you can't make it work for you. Coming from using AutoCAD and similar design programs where the tools are made to be used once, not drafted and then edited, it took a long time to become adjusted to Catia. I spent many hours trying to get Catia to work for me and failing miserably in one way or another. One of my most common errors was trying to work around using constraints all the time. I often either double clicked the line to set the length, or just set the length to begin with, rather than using the constraints properly. My first two drawings, the shaft tunnel and the intake took a lot of time. I would be drawing a line, update the constraint and suddenly the entire drawing would shift away from where it started. My first reaction was just to edit undo, overuse the "fix" constraint or remove the constraint entirely. It took a long time to get past that, work out how to understand the rules behind the constraints and figure out how to make them work for me, rather than force what I learnt using AutoCAD onto Catia. At one point however, about half way through February, Catia just clicked for me. That week I spent over 2 hours on Catia per day, updating past models where I'd missed out constraints and building a lot of models that I'd put off due to my lack of progress on the others. It became quite amusing when I was trying to use MB2+3 to zoom in and out on my computer in other applications and wondering why it wasn't working. In this time I also started the assembly, as it gave me a sense of accomplishment to see my model finally coming together.

One thing that particularly dogged me throughout the project was my inability to visualise how I would model the impeller part. This troubled me from the beginning, but I was able to put it off until I had completed the other parts. What was interesting was that none of my ideas in regards to how to draw it came while working on Catia, but rather at random points throughout the day. The day I remember in particular was the day where I finally figured out how to do the aerofoil section during a flight controls class and rushed to catch my supervisor to check my idea would work before going home and trying it out. When I got home, I was finally able to update my impeller from being simply a shaft to having a set of aerofoils on it. This was just a first draft, and would require a lot of tweaking until it was finally finished. It was soon after this that I realised that the plans I had downloaded from the Wren Turbine website (MW54) had a number of differences to the model we had in college (Wren 70), despite that they did share a number of similarities, and instead of accommodating these and using a mixture of plans and my own measurements using a set of digital callipers, it would be better to just use the plans, despite the design being more intricate and having more parts. It turned out that the Wren 54 was originally built in 2001, so named due to the 5.4kg of thrust it produced, and has since progressed onto the newer models; the Wren 70, 75, 75 Jubilee and the current model, the Wren 80 Jubilee which has 8kg of thrust. The biggest changes from the MW54 to the Wren 70 are the model of impeller used, an updated diffuser, vaporiser tubes, exhaust nozzle and casing. Other than that, they are extremely similar. The NGV is identical, as is the shaft and shaft tunnel, the main combustion chamber, bearings, front and rear spacer, spring and preload tube. However, the small changes that the turbojet has gone through have resulted in an increase from 5.4kg of thrust to 8kg. In using the Wren 54 plans, I was able to use exact dimensions and not have to rely on the digital callipers and estimation.

Over the course of the project there were three main parts that in a way defined my work with Catia. Firstly the intake, one of my early parts, which took around 1-2 hours to complete. If I were to go back and do the same part now, I would be able to do it in around 5 minutes. I have at times and had to redo models, such as the shaft tunnel, again, because there was an error with Catia that wouldn't let it create a section view. Redoing the part took minutes, which, as it was one of my first parts along with the intake, took 1-2 hours to complete. The other major part was of course the impeller, which when I had finally completed it, the sense of achievement was remarkable. Lastly is the outlet vane, part of the cone assembly, that caused me such trouble right at the end of the project. It showed me some of the drawbacks that Catia has, in the sense of part design, and showed me what I had to move on to next to continue my development in Catia; namely using the generative shape design workbench, which lets you generate almost any conceivable shape, although it means that building a simple object such as a cube takes much longer, however it allows you to build advanced aerofoil designs and gives you unlimited freedom in what you want to develop. Another aspect that I would like to pursue in more detail when I have the available time is to use Autodesk 3DS Max for rendering. I started to use it and toy around with the various tools, but it was too complicated to produce a good looking model in such a late stage of development. My next projects are to complete my rendering of the Wren MW54 and then go on to model the turboshaft and the chassis and sheetmetal for my grandpa's upcoming Jazag 8 single seater.





# References & Resources

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| | |
|---|---|
| Autodesk 3DS Max 2015 Student Version | Rendering Software |
| Catia v5r21 Student Edition | 3D Modelling software |
| Microsoft Project 2013 | Project Planning software |
| Microsoft Word 2013 | Word Processor |
| MindNode Pro | Mind-mapping software |
| Numbers 3.2 | Spreadsheet Editor |
| Pages 5.2, 4.3 | Word Processor |
| Paint | Screenshot Editing |
| Preview 7.0 | PDF Editor |

Final Word Count: 11296

(Full Document: 11650)

# Appendix I - Project Specification & Plans

## Project Specification

Project Brief:

In this project, my aim is to follow a design process model, become thoroughly acquainted with Catia v5r20, producing 2D sketches and finally a complete 3D model of a Wren Engine. This will include introductory tutorials in Catia, as well as research into the gas turbine engine.

List of Objectives

- Increase knowledge of Catia v5
- Improve understanding of design process
- Improve understanding of project management
- Increase knowledge of gas turbine engine
- Gain knowledge of miniature Wren engine
- Produce 3D model and 2D drawings of design
- Produce coherent and well structured final submission

Deliverables:

- Written Submission
- 3D Models
- 2D Drawings

Exclusions

- No final product
- No physical models

Constraints

- Time

Interfaces

- Tony Leslie; Project Supervisor

Acceptance Criteria

- Report Guidance Document

- Checklist (Moodle)
- Signed Declaration Statement

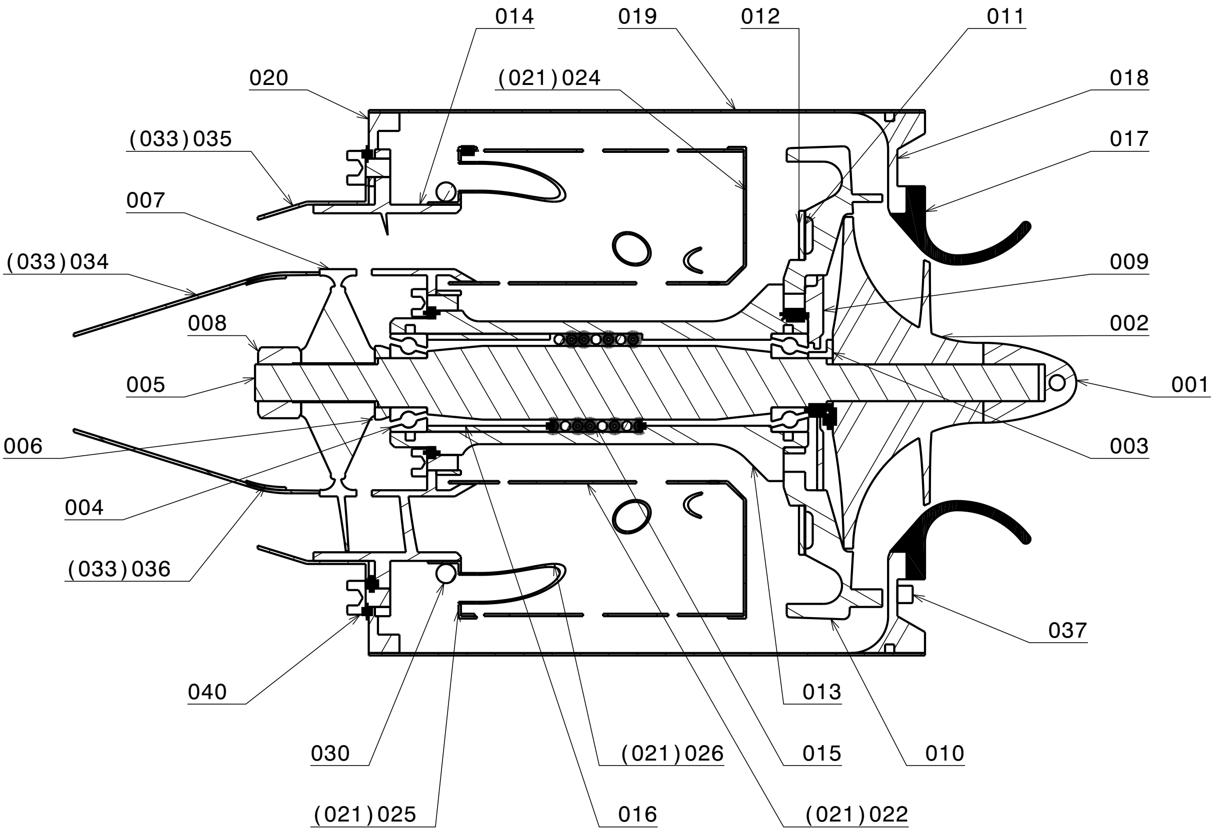
Resources

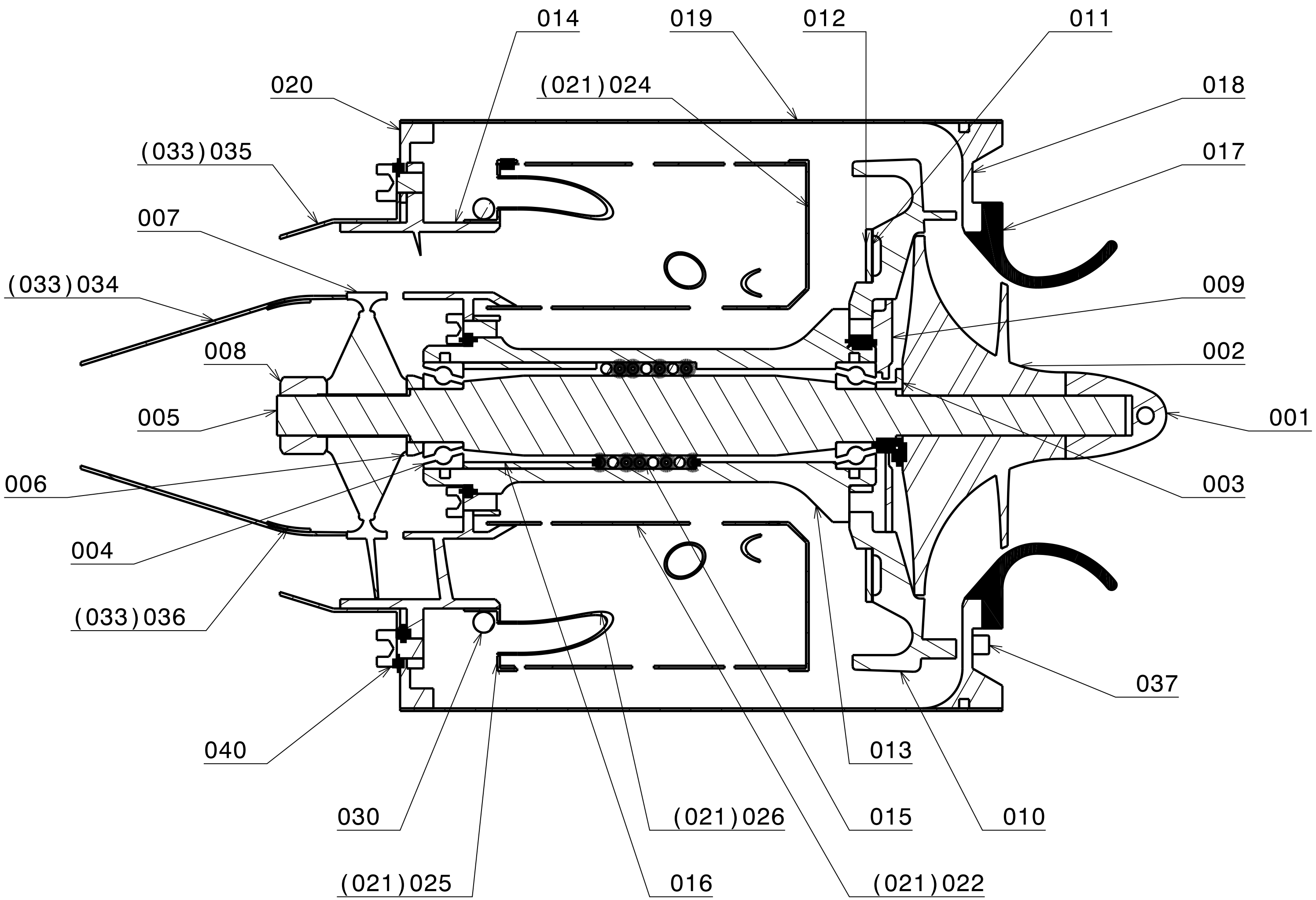
- Catia v5r20
- Microsoft Project
- Microsoft Word
- iWork
- MindNode Pro
- Wren Engine

Risks

- Injury
- Illness
- Workload from other subjects
- Computer failure

# Appendix II - 2D Plans

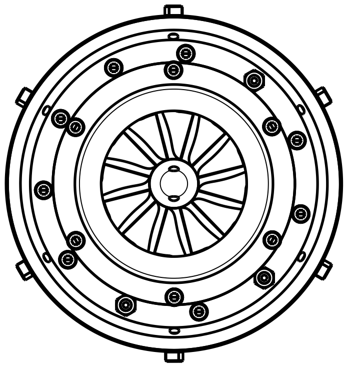




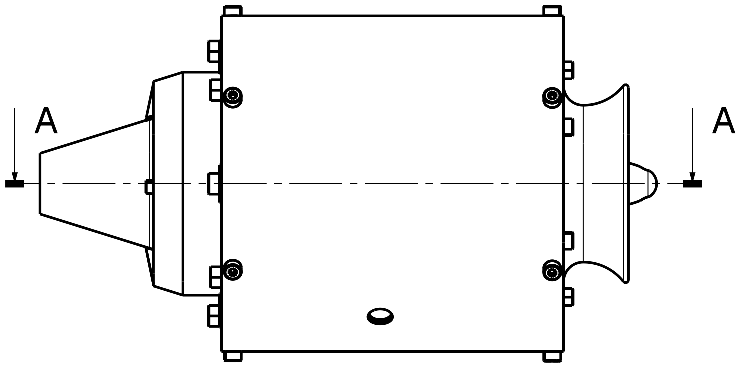

Dimensions in mm

Section cut A-A
Scale: 1:1

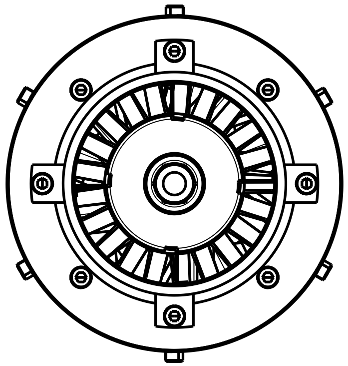
| | |
|---|---|
| Part Number | 000 Sheet 1 |
| Part Name | Assembly |
| Material | Various |
| Author | Thomas Dickinson |



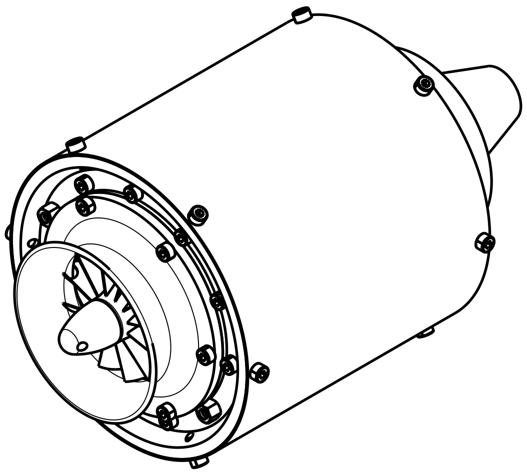
Right view
Scale: 1:2




Front view
Scale: 1:2



Left view
Scale: 1:2

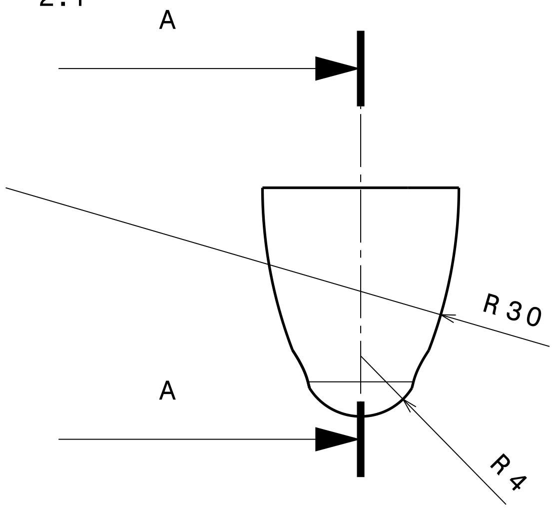


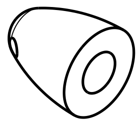
Isometric view
Scale: 1:2

Dimensions in mm

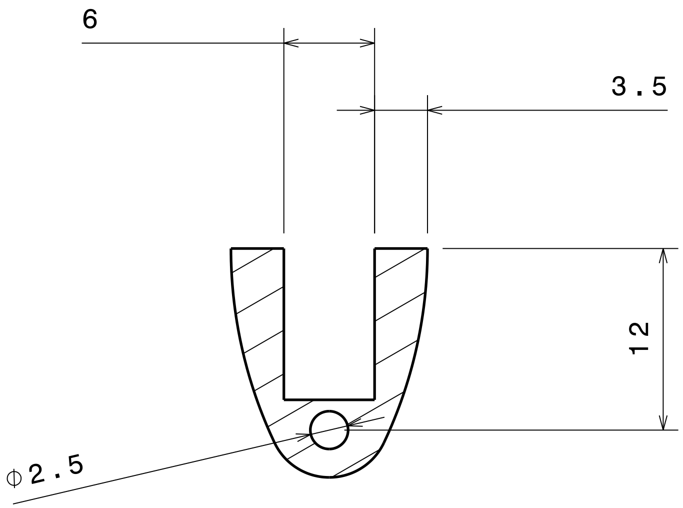
| | |
|---|---|
| Part Number | 000 Sheet 1 |
| Part Name | Assembly |
| Material | Various |
| Author | Thomas Dickinson |

Front view
Scale:  2:1

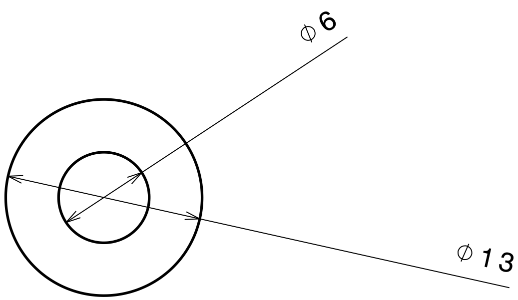


Isometric view
Scale:  1:1



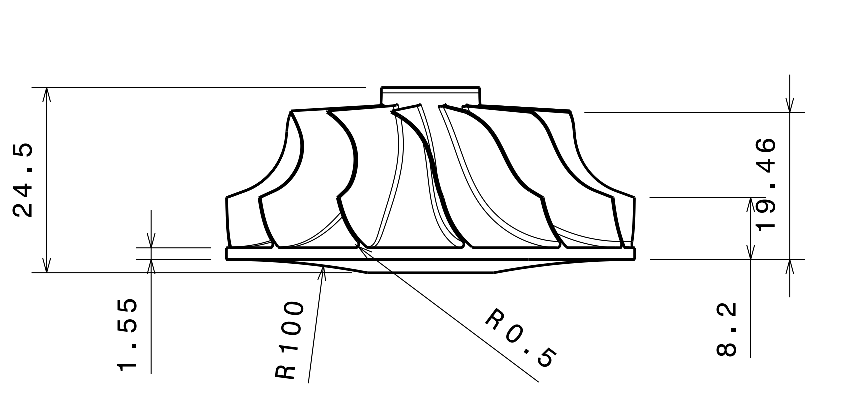

Section cut A-A
Scale:  2:1



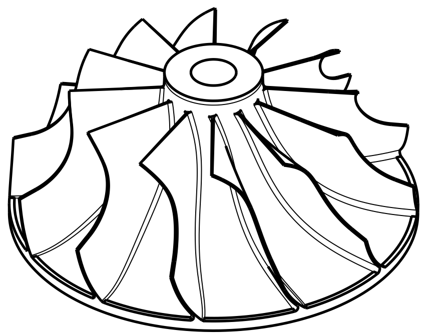

Top view
Scale:  2:1

Dimensions in mm

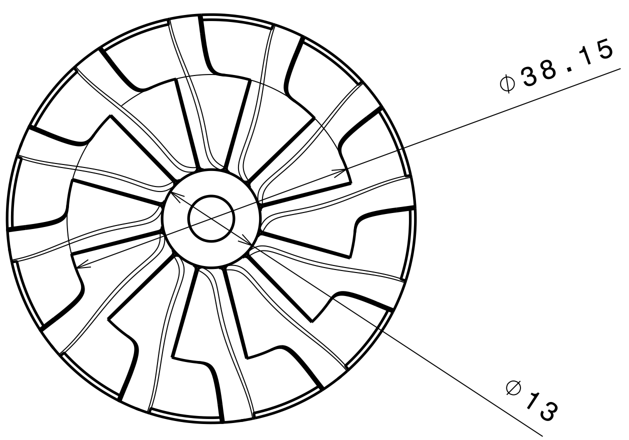
| | |
|---|---|
| Part Number | 001 |
| Part Number | Compressor Nut |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |



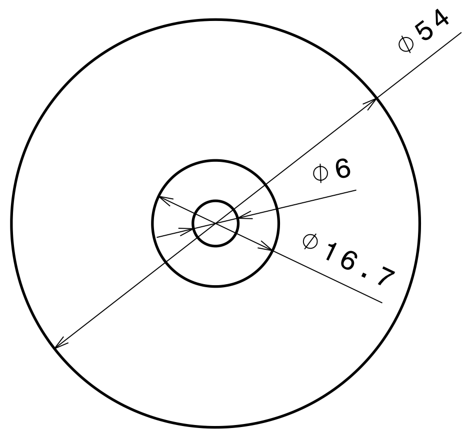

Bottom view
Scale: 1:1



Isometric view
Scale: 1:1




Front view
Scale: 1:1

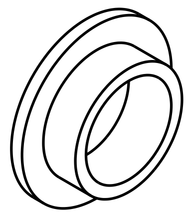



Rear view
Scale: 1:1

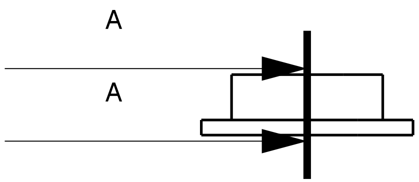
Dimensions in mm

| | |
|---|---|
| Part Number | 002 |
| Part Name | Impeller |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |

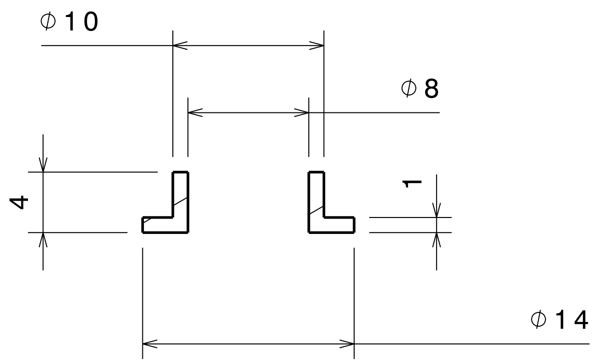
Dimensions in mm



Isometric view
Scale:  2:1

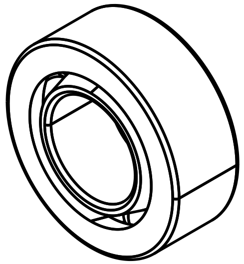



Front view
Scale:  2:1

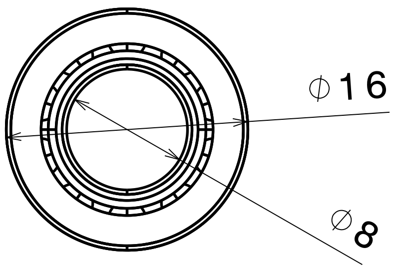



Section cut A-A
Scale:  2:1

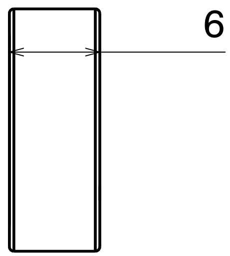
| | |
|---|---|
| Part Number | 003 |
| Part Name | Front Spacer |
| Material | Mild Steel |
| Author | Thomas Dickinson |



Isometric view
Scale: 2:1



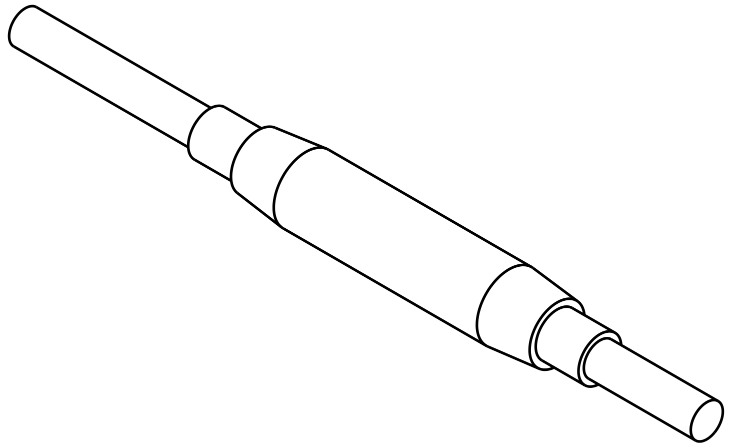

Right view
Scale: 2:1



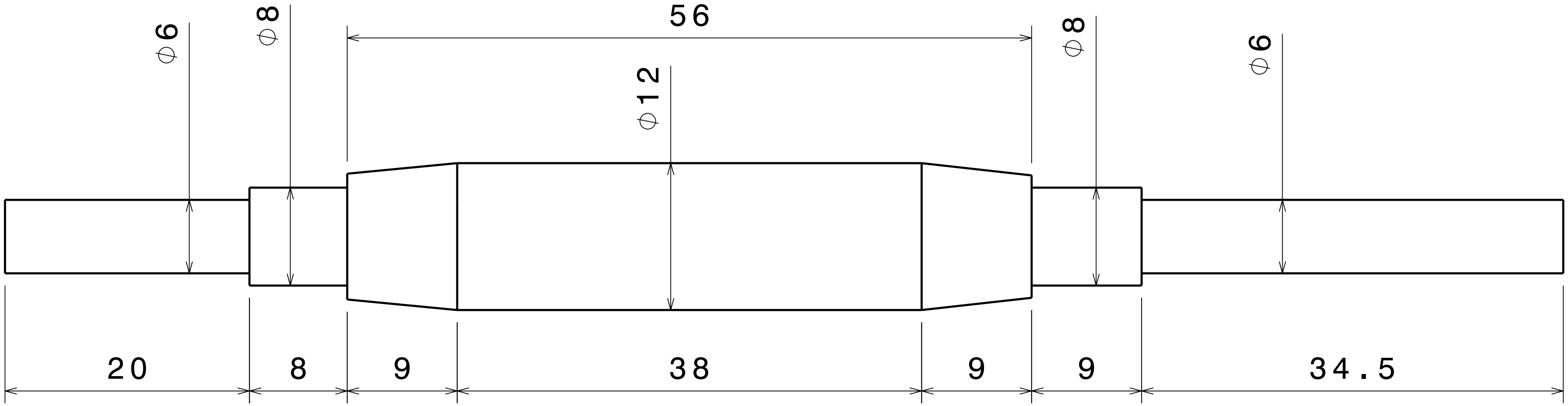

Front view
Scale: 2:1

Dimensions in mm

| | |
|---|---|
| Part Number | 004 |
| Part Name | D688/602 Bearing |
| Material | Silicon Nitride, Stainless Steel |
| Author | Boca Bearings |



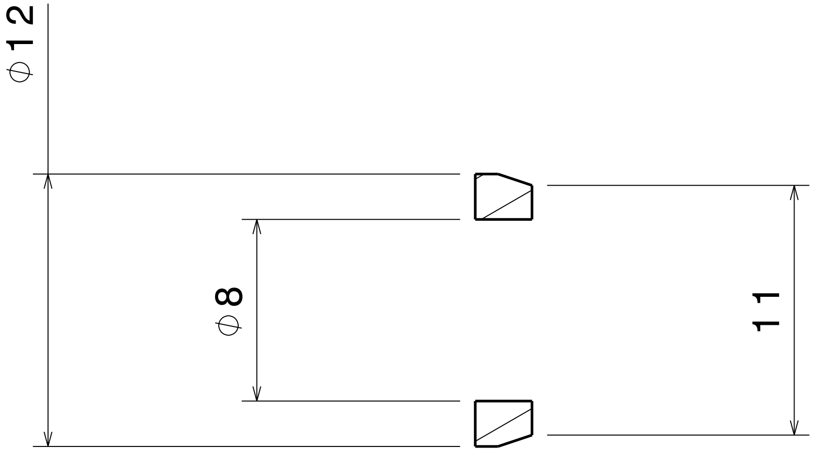
Isometric view
Scale: 1:1



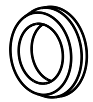

Front view
Scale: 2:1

Dimensions in mm

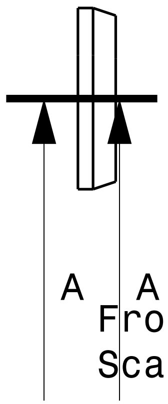
| | |
|---|---|
| Part Number | 005 |
| Part Name | Shaft |
| Material | En 24T |
| Author | Thomas Dickinson |




Section cut A-A
Scale: 3:1



Isometric view
Scale: 1:1

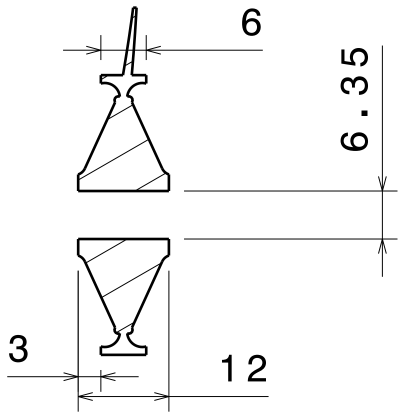


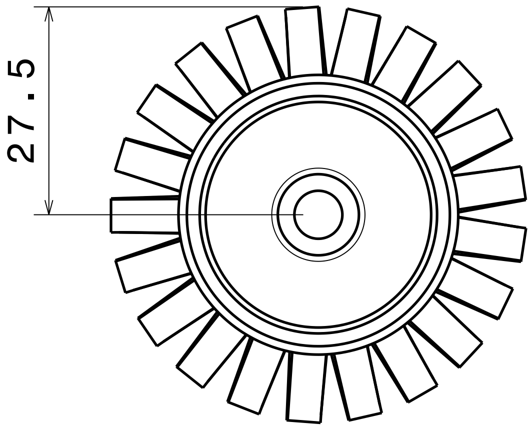

Front view
Scale: 2:1

Dimensions in mm

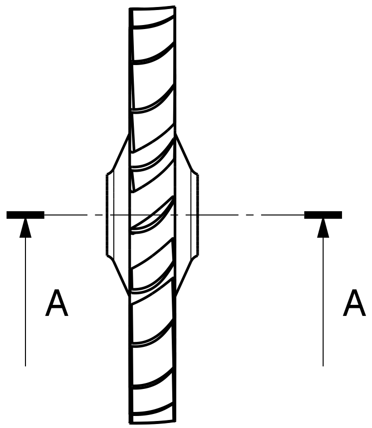
| | |
|---|---|
| Part Number | 006 |
| Part Name | Rear Spacer |
| Material | Stainless Steel |
| Author | Thomas Dickinson |

Section cut A-A
Scale: 1:1



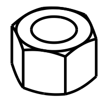

Right view
Scale: 1:1



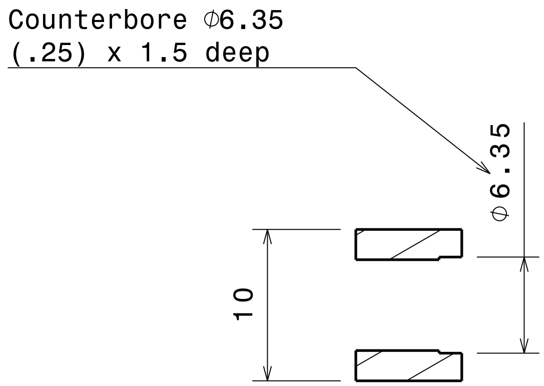

Front view
Scale: 1:1

Dimensions in mm

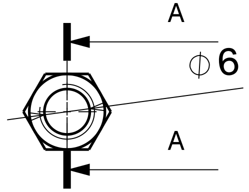
| | |
|---|---|
| Part Number | 007 |
| Part Name | Turbine |
| Material | Inconel |
| Author | Thomas Dickinson |



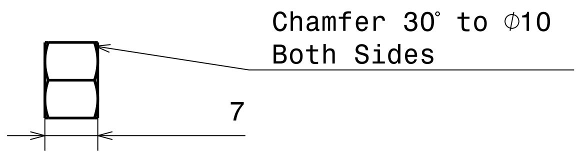
Isometric view
Scale: 1:1




Section cut A-A
Scale: 2:1



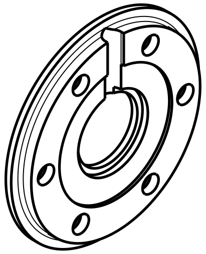

Front view
Scale: 1:1



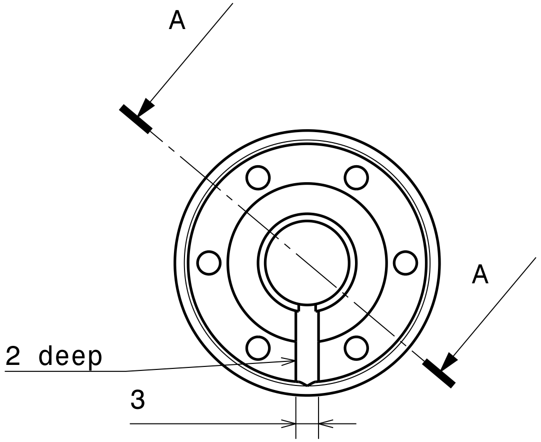

Left view
Scale: 1:1

Dimensions in mm

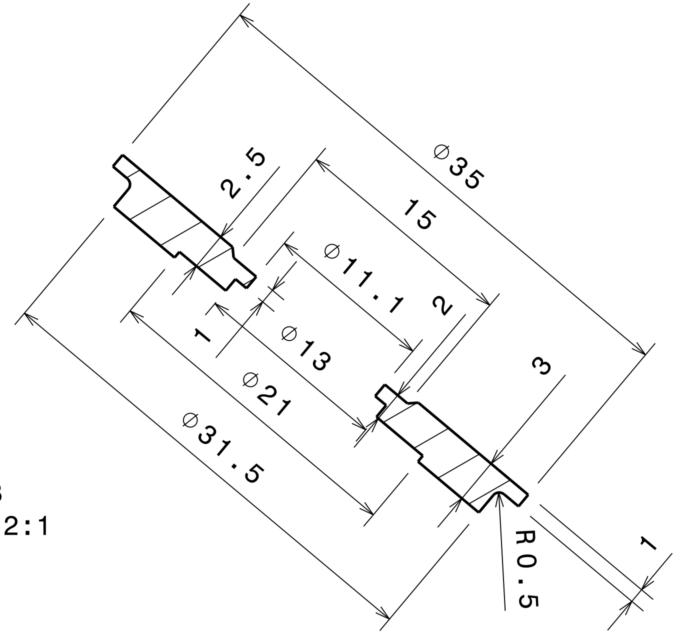
| | |
|---|---|
| Part Number | 008 |
| Part Name | Turbine Nut |
| Material | Stainless Steel |
| Author | Thomas Dickinson |



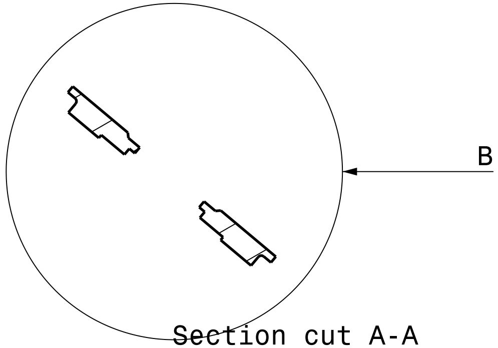
Isometric view
Scale: 1:1



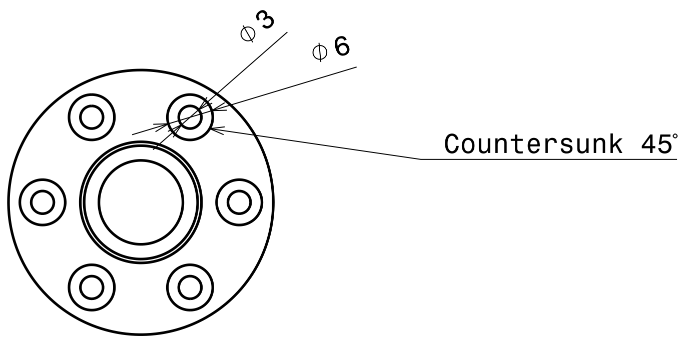

Top view
Scale: 1:1




Detail B
Scale: 2:1



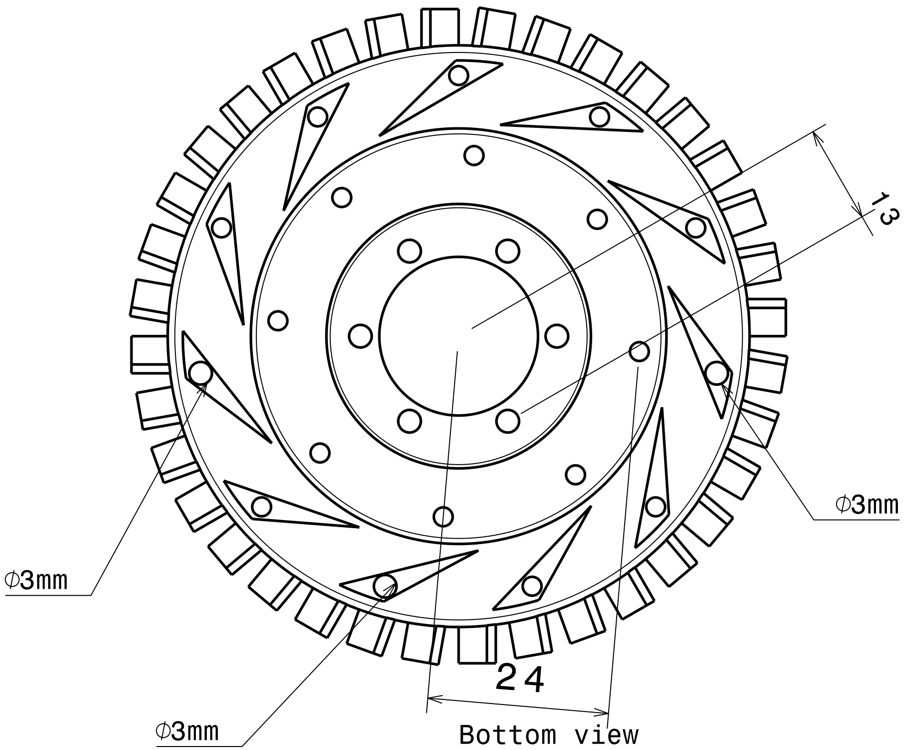

Section cut A-A
Scale: 1:1



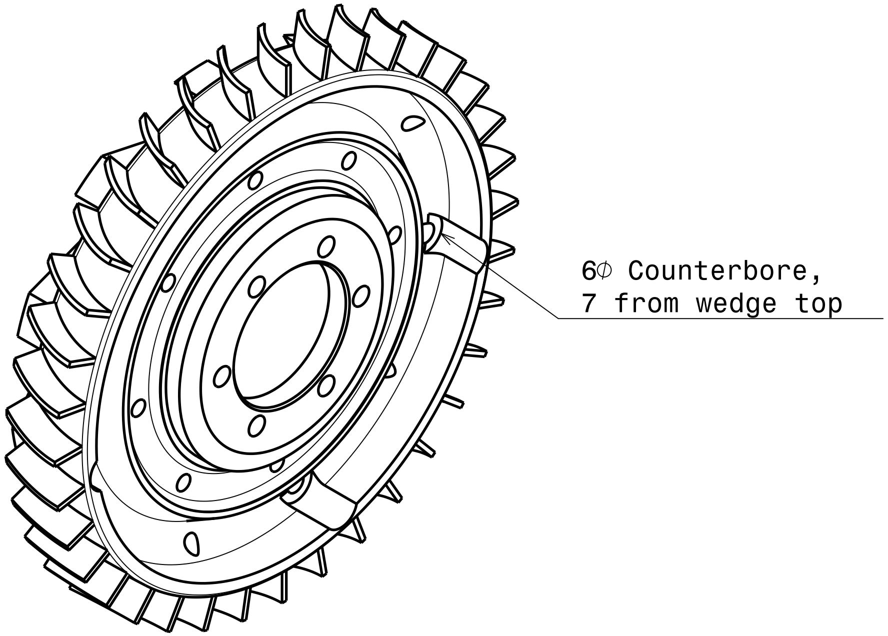

Front view
Scale: 1:1

Dimensions in mm

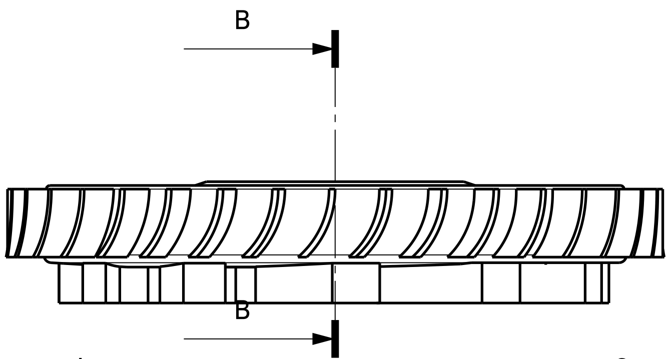
| | |
|---|---|
| Part Number | 009 |
| Part Name | Shaft Seal |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |



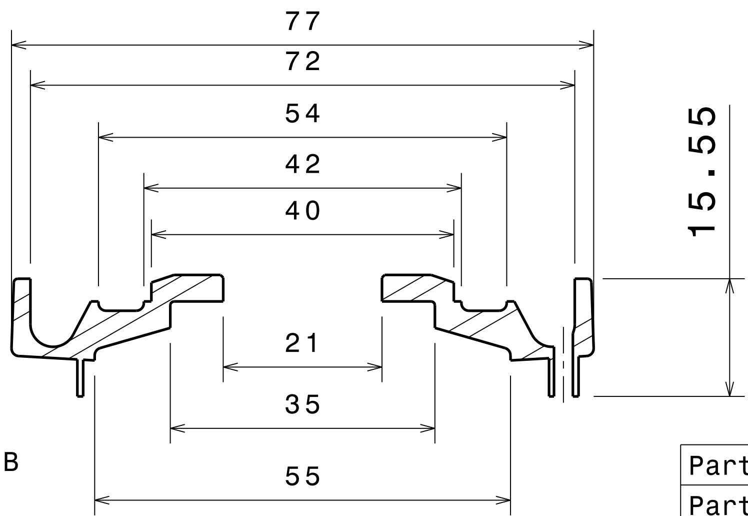

Bottom view
Scale: 1:1




Isometric view
Scale: 1:1



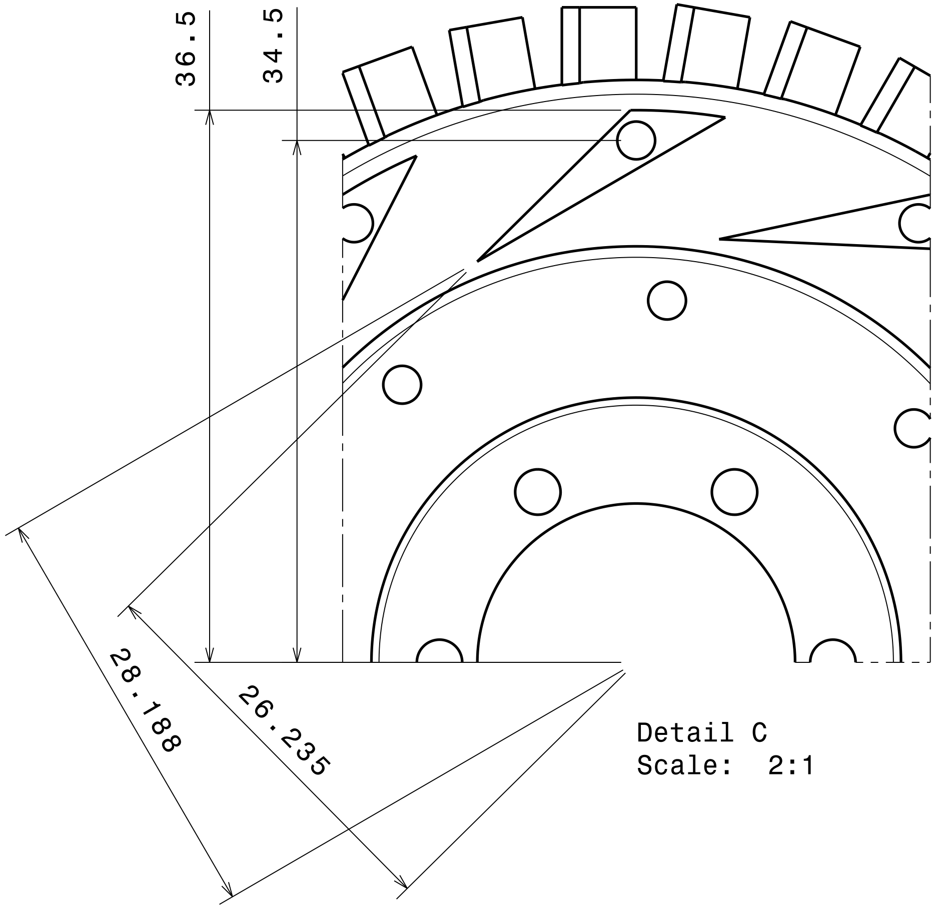

Front view
Scale: 1:1



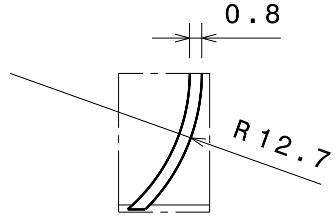

Section cut B-B
Scale: 1:1

Dimensions in mm

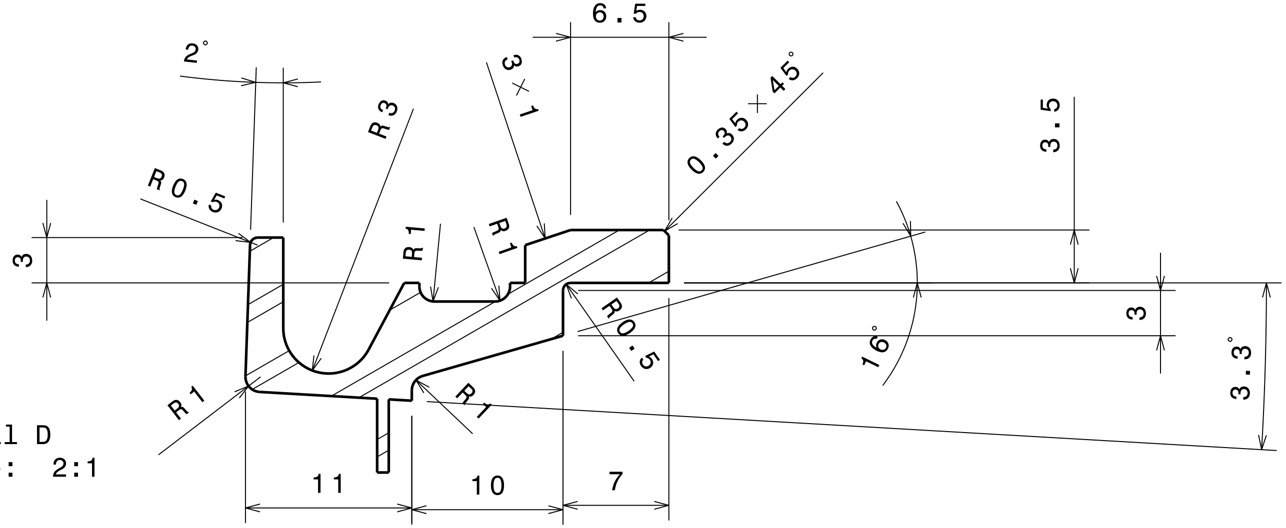
| | |
|---|---|
| Part Number | 010 Sheet 1 |
| Part Name | Diffuser |
| Material | Alluminium Alloy |
| Author | Thomas Dickinson |




Detail C
Scale: 2:1



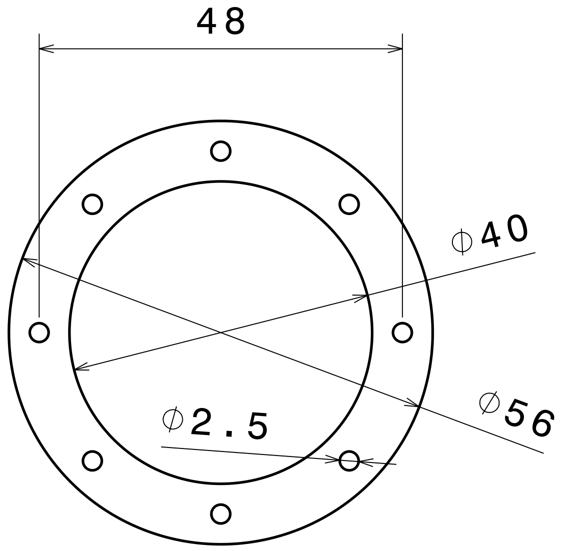

Detail A
Scale: 2:1



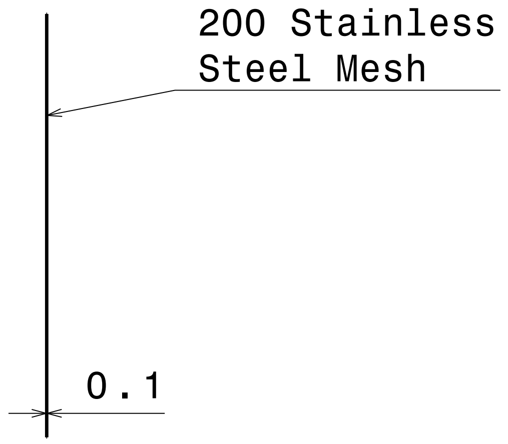

Detail D
Scale: 2:1

Dimensions in mm

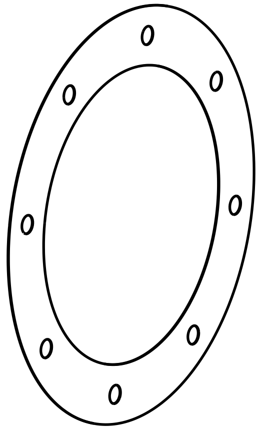
| | |
|---|---|
| Part Number | 010 Sheet 2 |
| Part Name | Diffuser |
| Material | Alluminium Alloy |
| Author | Thomas Dickinson |




Right view
Scale: 1:1



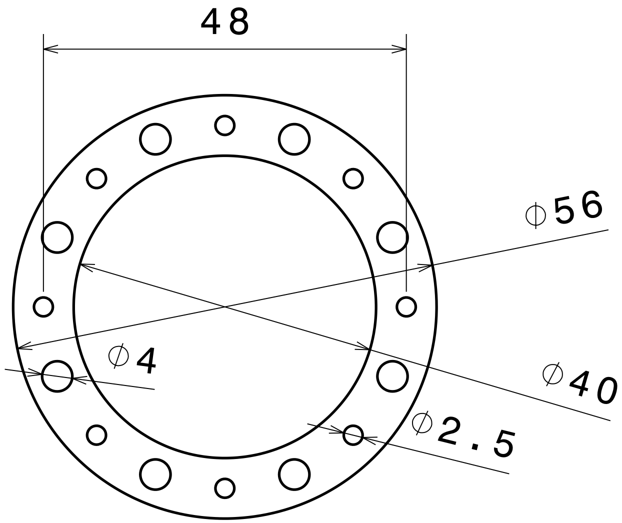

Front view
Scale: 1:1



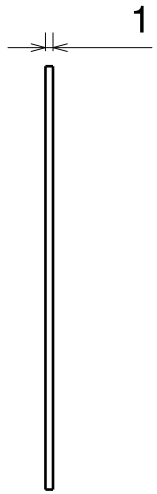
Isometric view
Scale: 1:1

Dimensions in mm

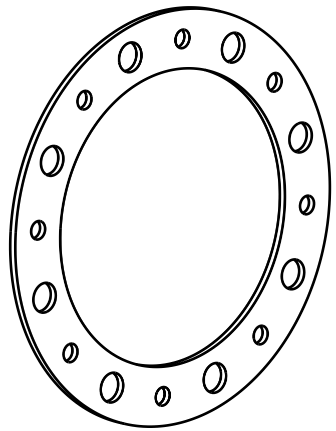
| | |
|---|---|
| Part Number | 011 |
| Part Name | Filter |
| Material | .005 Stainless Steel Mesh |
| Author | Thomas Dickinson |




Right view
Scale: 1:1



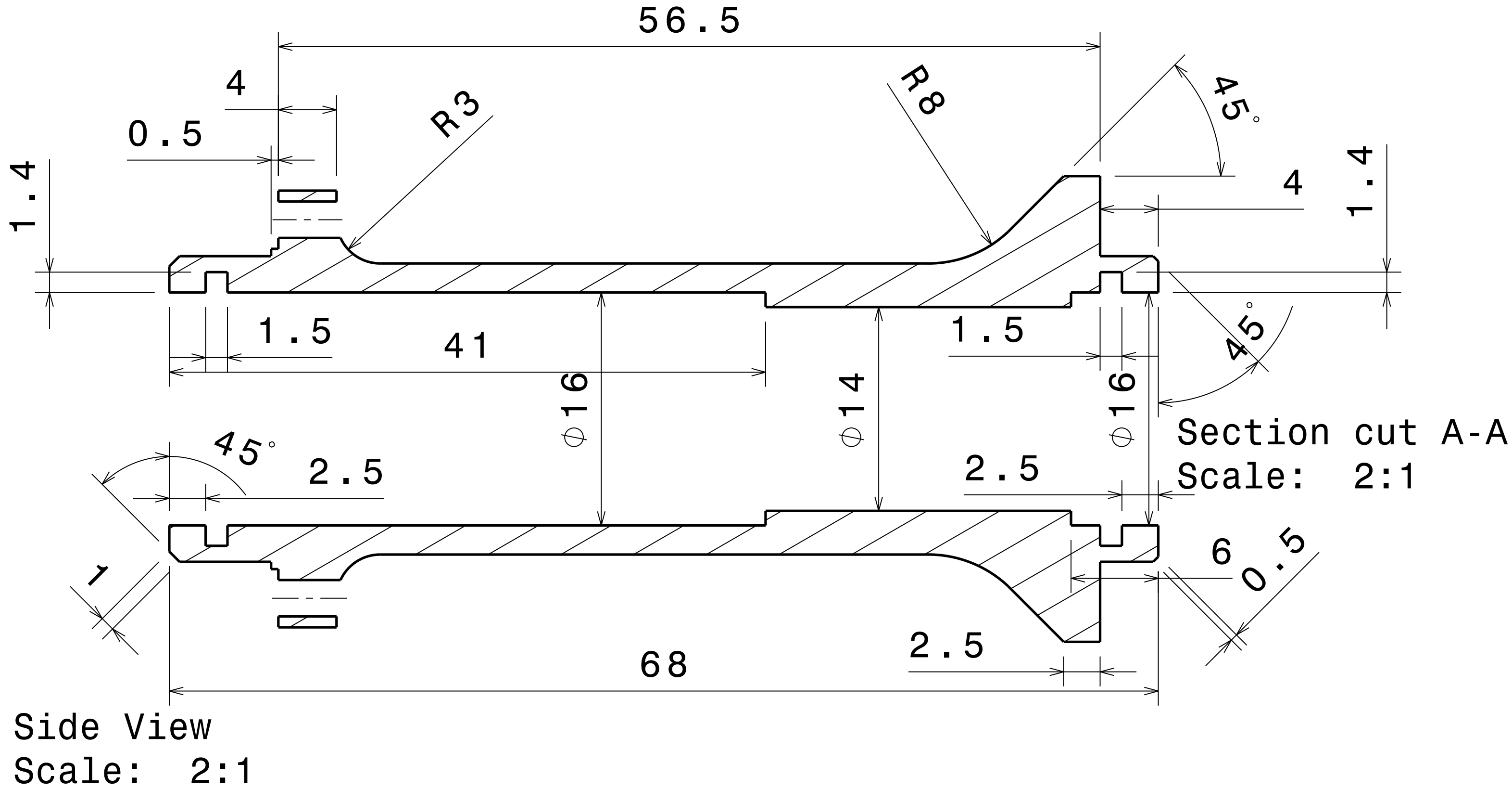

Front view
Scale: 1:1

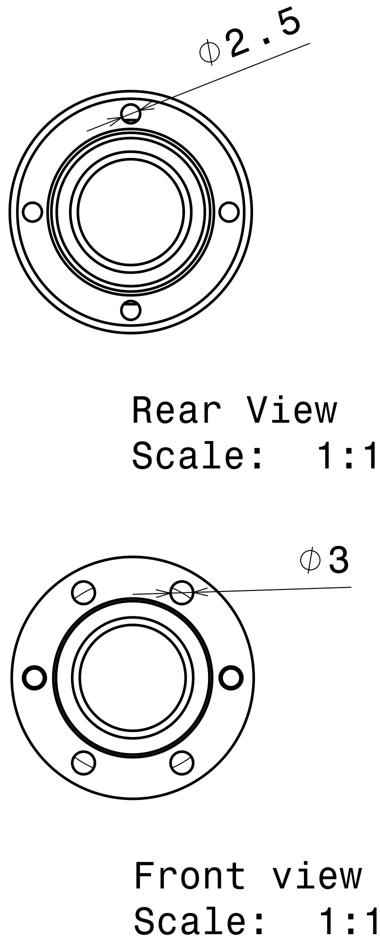


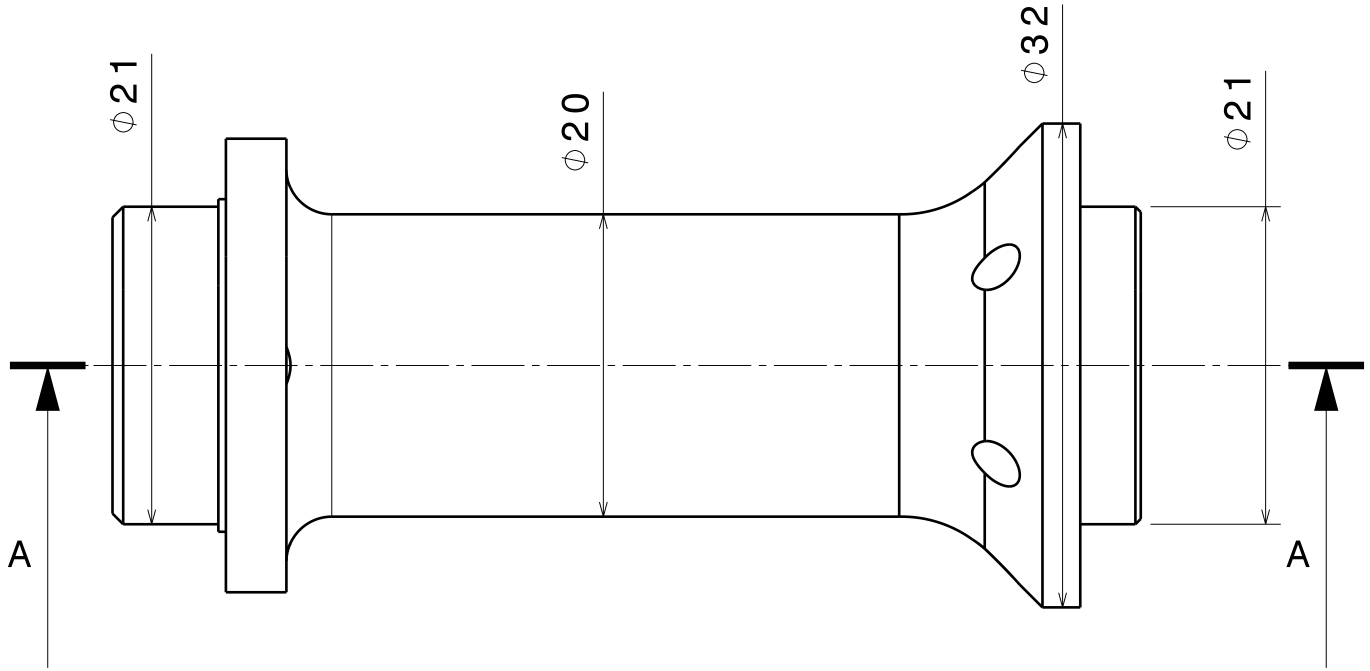
Isometric view
Scale: 1:1

Dimensions in mm

| | |
|---|---|
| Part Number | 012 |
| Part Name | Filter Cover |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |

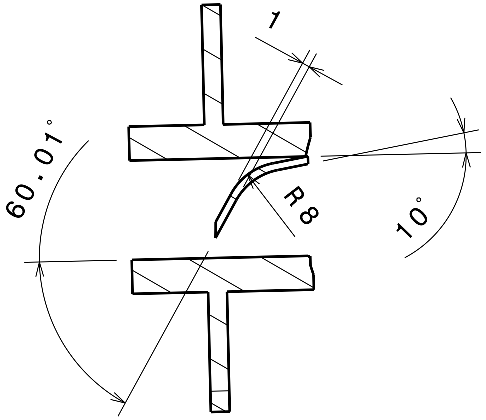


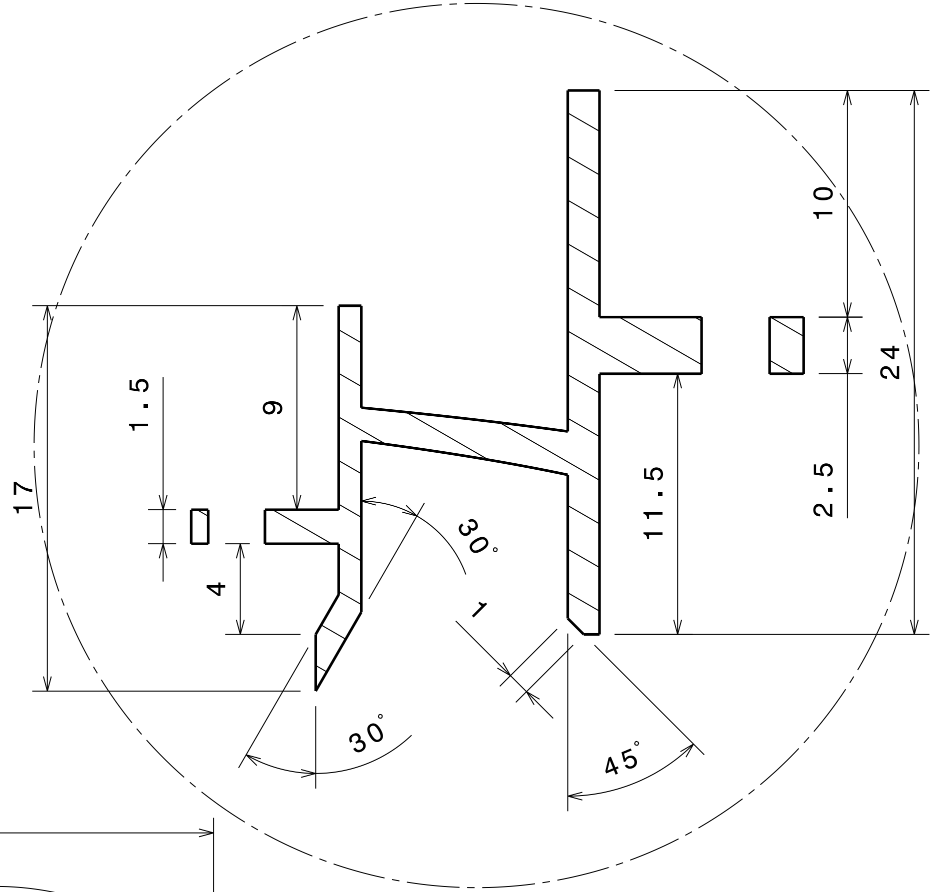

Dimensions in mm

| | |
|---|---|
| Part Number | 013 |
| Part Name | Shaft Tunnel |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |

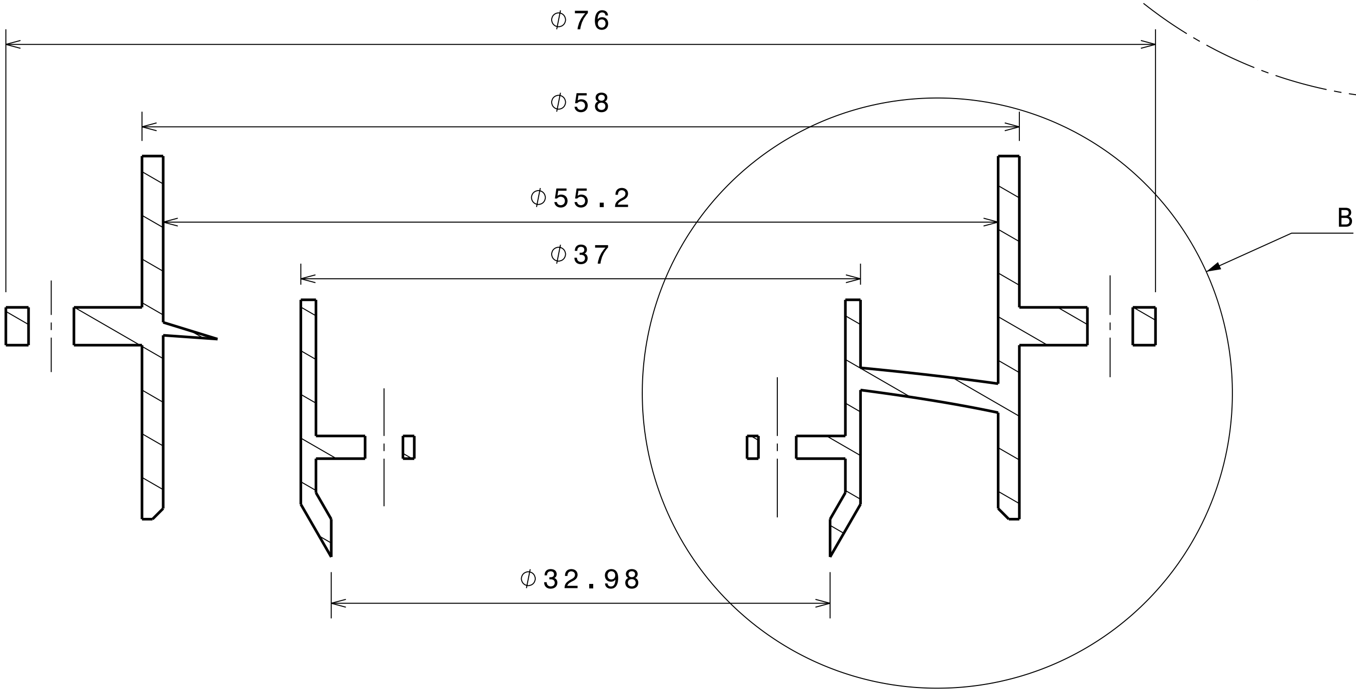



Section cut B-B
Scale: 1:1

Detail B
Scale: 3:1

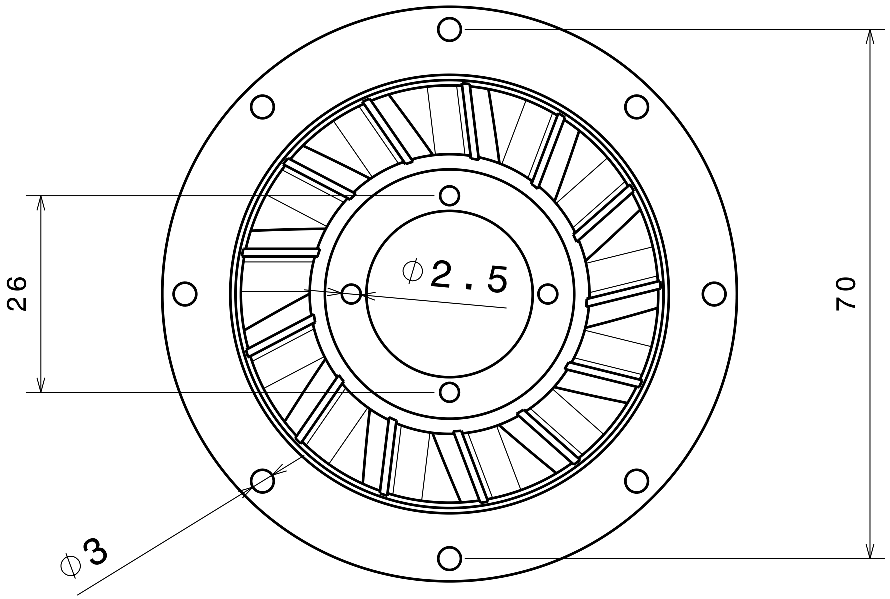



Section cut A-A
Scale: 2:1

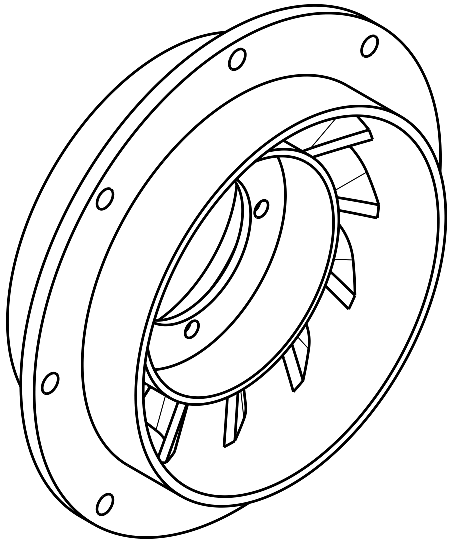



Dimensions in mm

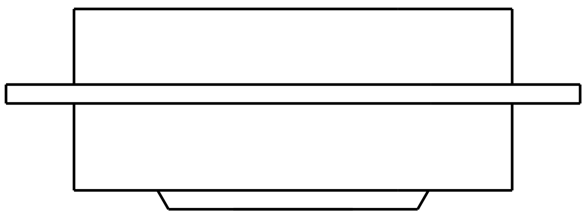
| | |
|---|---|
| Part Number | 023 Sheet 2 |
| Part Name | Nozzle Guide Vanes |
| Material | Stainless Steel |
| Author | Thomas Dickinson |




Bottom view
Scale: 1:1



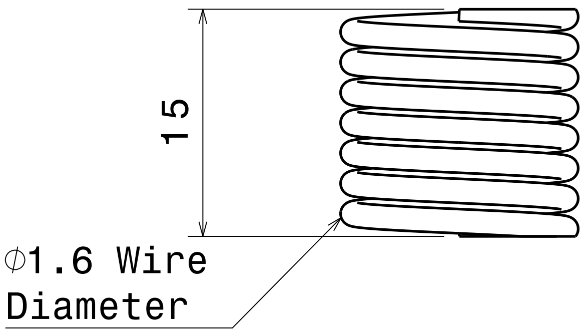
Isometric view
Scale: 1:1



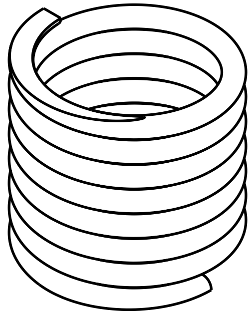
Front view
Scale: 1:1

Dimensions in mm

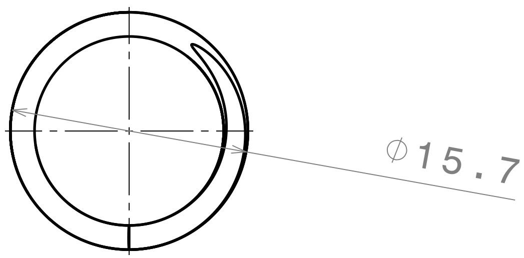
| | |
|---|---|
| Part Number | 014 Sheet 1 |
| Part Name | Nozzle Guide Vanes |
| Material | Stainless Steel |
| Author | Thomas Dickinson |




Bottom view
Scale: 2:1



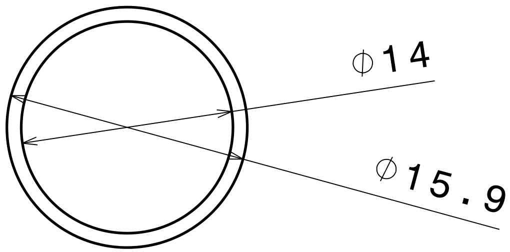
Isometric view
Scale: 2:1



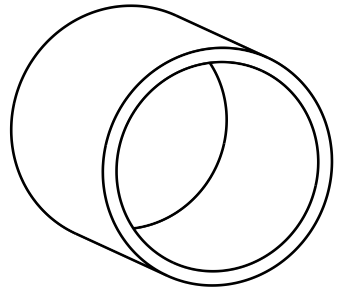

Front view
Scale: 2:1

Dimensions in mm

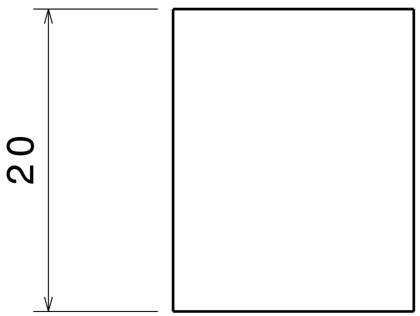
| | |
|---|---|
| Part Number | 015 |
| Part Name | Spring |
| Material | Spring Steel |
| Author | Thomas Dickinson |




Bottom view
Scale: 2:1



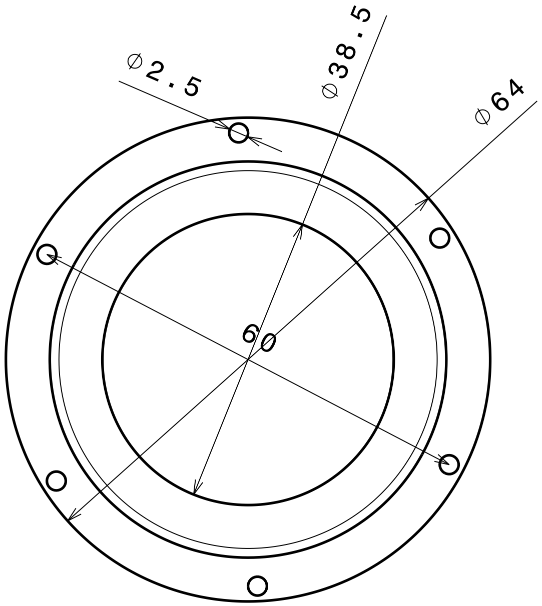
Isometric view
Scale: 2:1



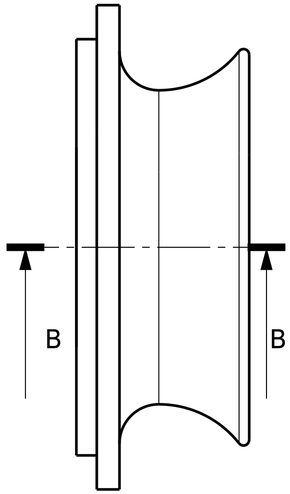

Front view
Scale: 2:1

Dimensions in mm

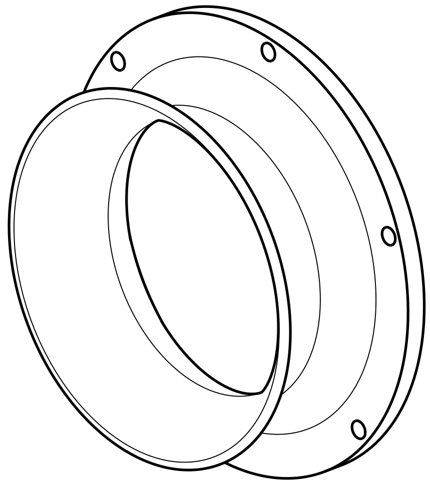
| | |
|---|---|
| Part Number | 016 |
| Part Name | Preload Tube |
| Material | Mild Steel |
| Author | Thomas Dickinson |



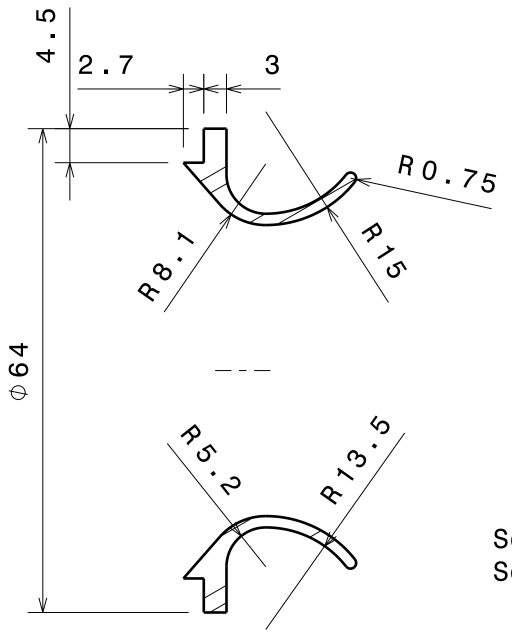

Right view
Scale: 1:1




Front view
Scale: 1:1



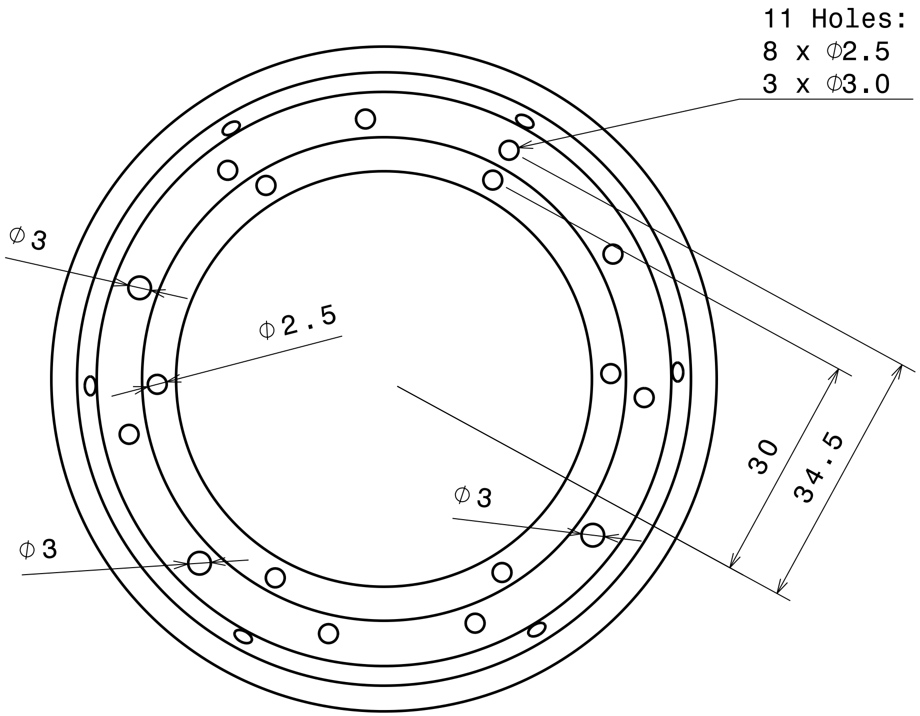
Isometric view
Scale: 1:1



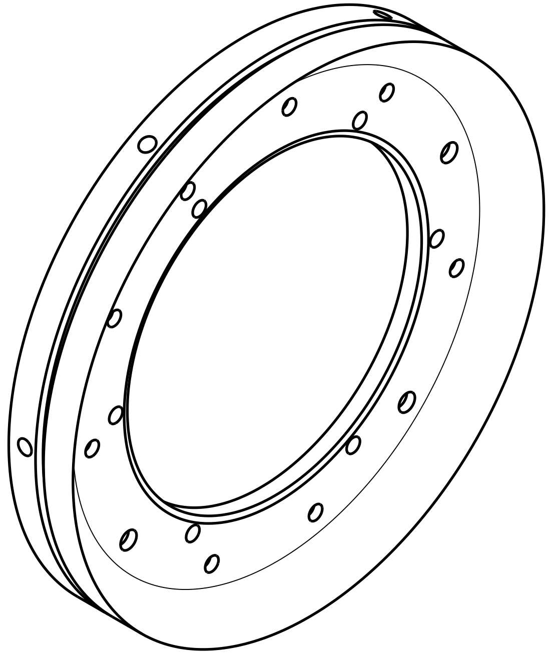

Section cut B-B
Scale: 1:1

Dimensions in mm

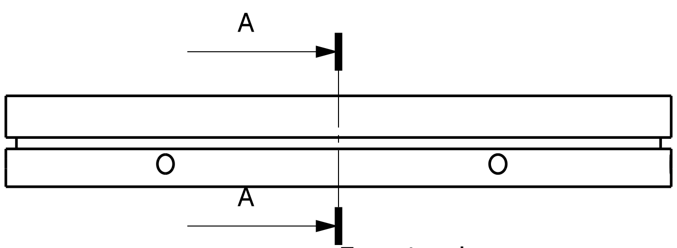
| | |
|---|---|
| Part Number | 017 |
| Part Name | Intake |
| Material | Nylon |
| Author | Thomas Dickinson |



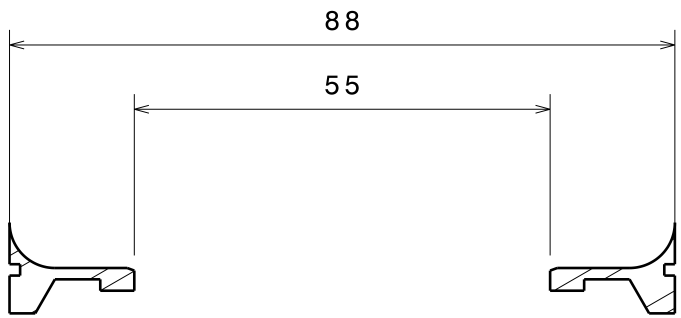

Bottom view
Scale: 1:1



Isometric view
Scale: 1:1



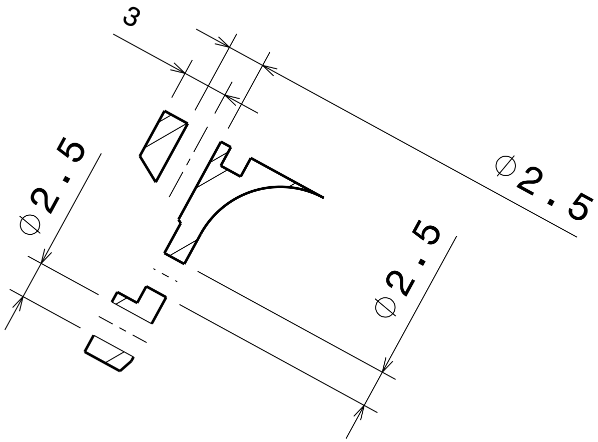

Front view
Scale: 1:1



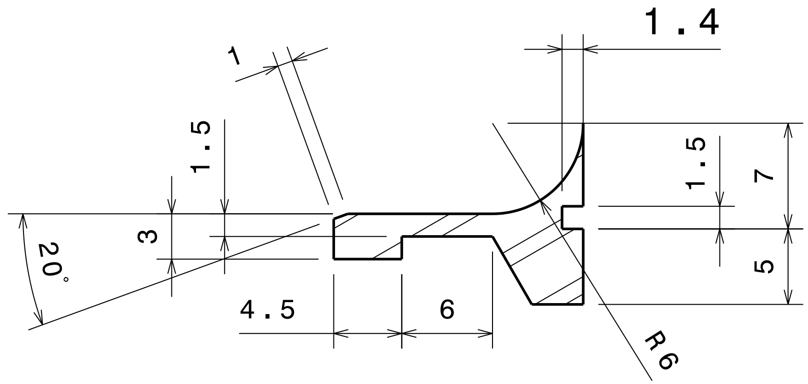

Section cut A-A
Scale: 1:1

Dimensions in mm

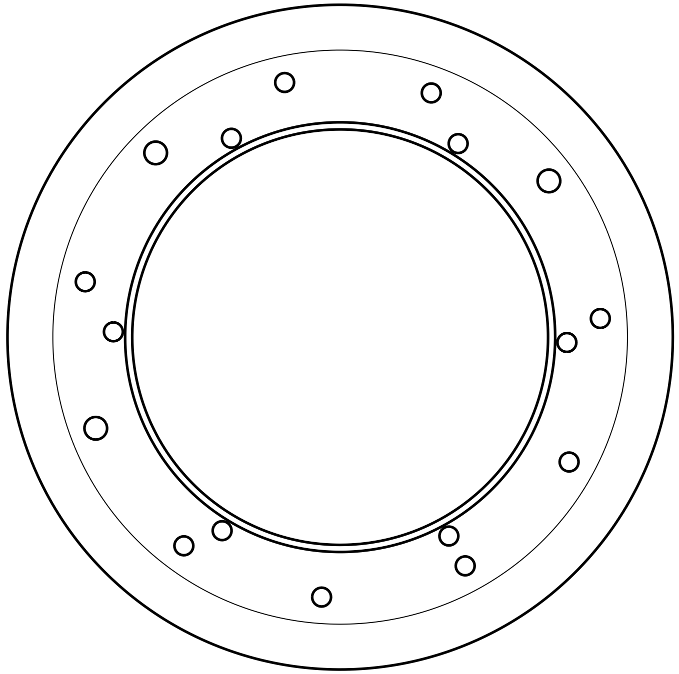
| | |
|---|---|
| Part Number | 018 Sheet 1 |
| Part Name | Case Front |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |




Section cut C-C
Scale: 2:1




Detail B
Scale: 2:1



Top view
Scale: 1:1

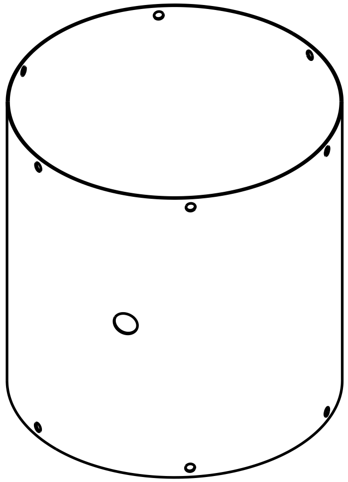
Dimensions in mm

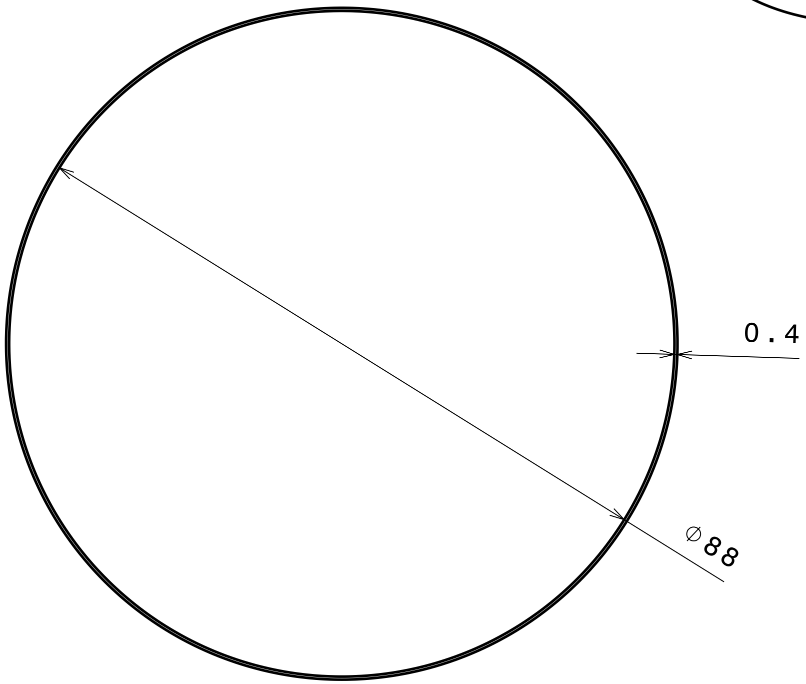
| | |
|---|---|
| Part Number | 018 Sheet 2 |
| Part Name | Case Front |
| Material | Aluminium Alloy |
| Author | Thomas Dickinson |

Dimensions in mm

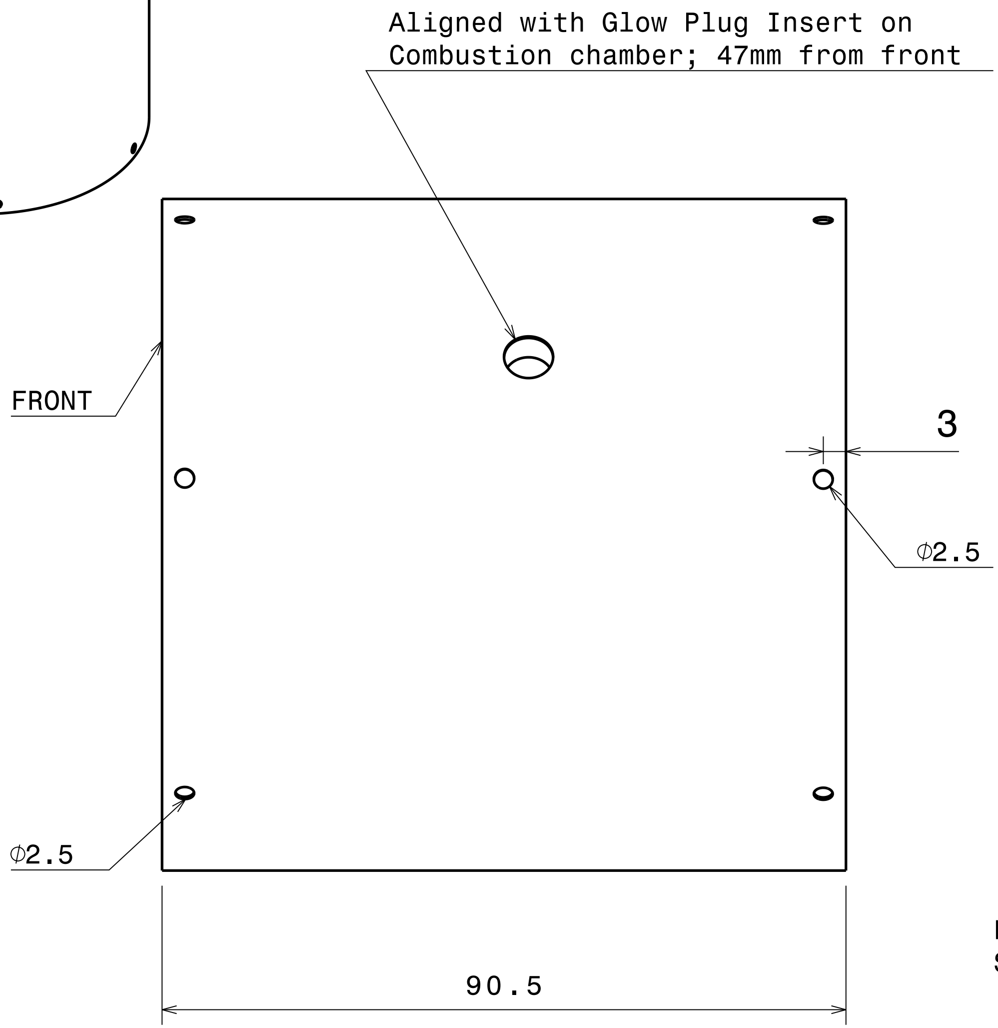
| | |
|---|---|
| Part Number | 019 |
| Part Name | Case Outer |
| Material | .4mm Stainless Steel Sheet |
| Author | Thomas Dickinson |

Isometric view
Scale: 1:2



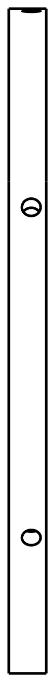


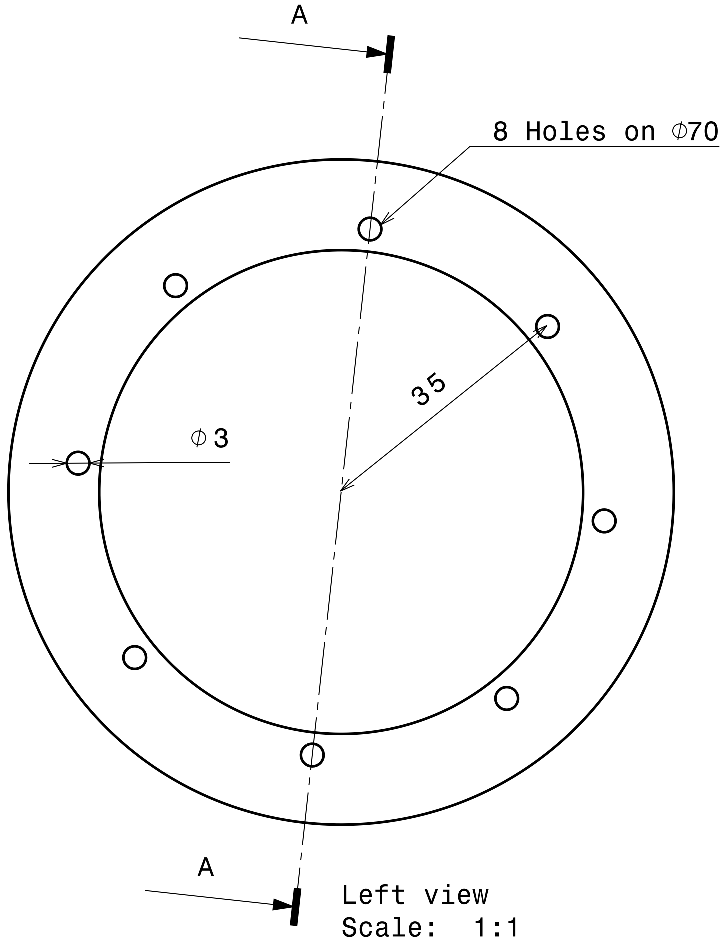

Front view
Scale: 1:1



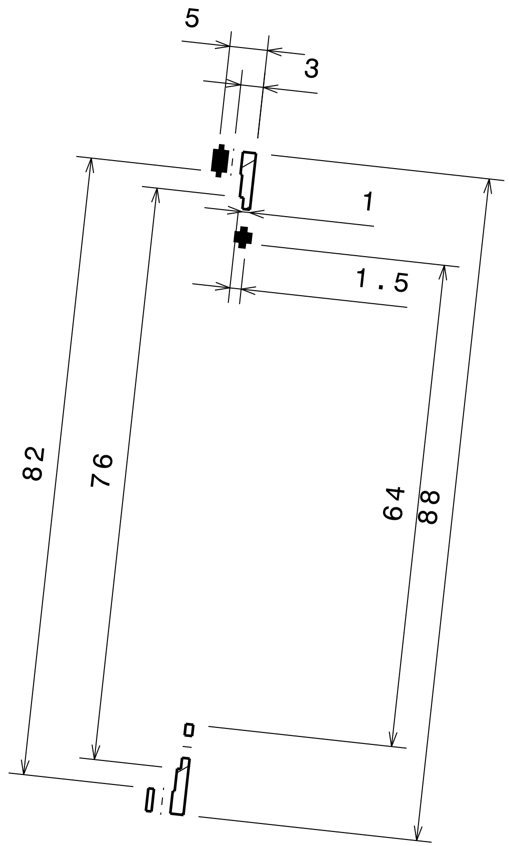

Left view
Scale: 1:1

Front view
Scale:  1:1

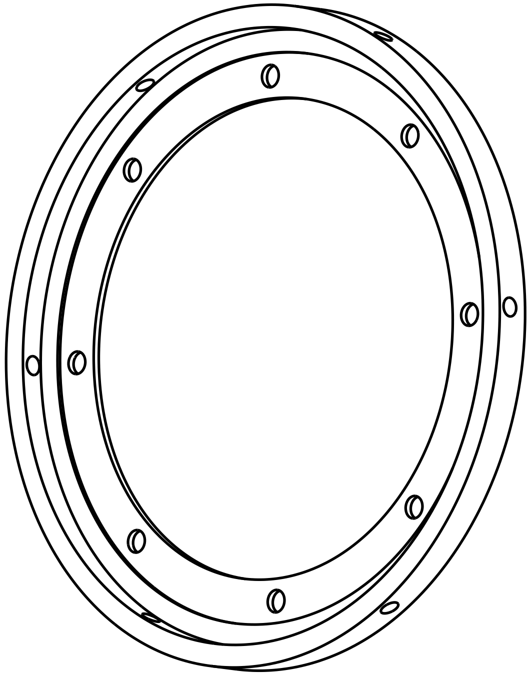





Left view
Scale:  1:1



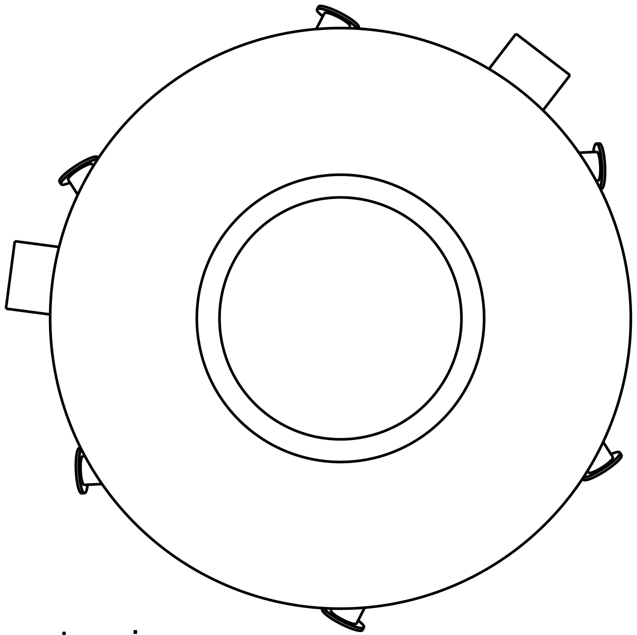

Section cut A-A
Scale:  1:1



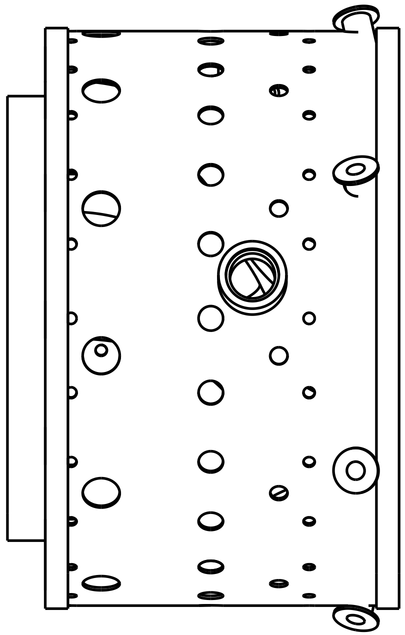
Isometric view
Scale:  1:1

Dimensions in mm

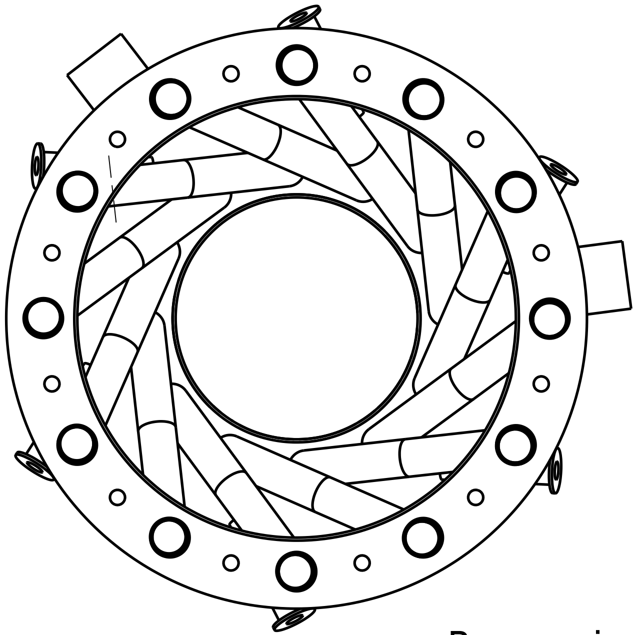
| | |
|---|---|
| Part Number | 020 |
| Part Name | Case Rear |
| Material | Mild Steel |
| Author | Thomas Dickinson |



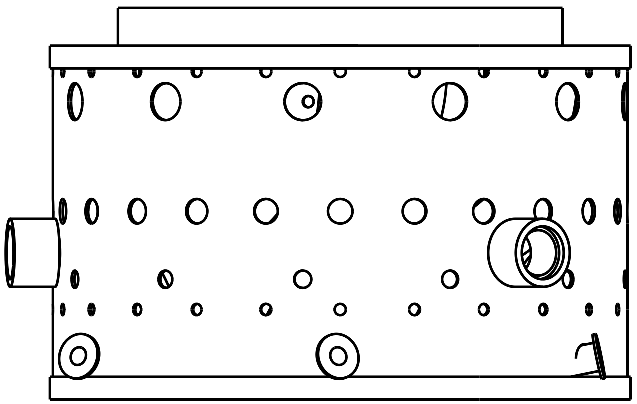
Front view
Scale: 1:1



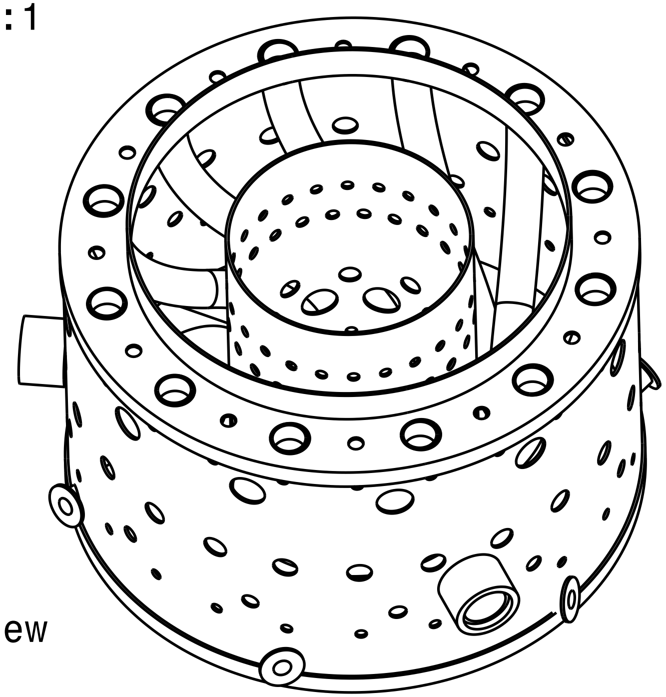
Left view
Scale: 1:1



Rear view
Scale: 1:1



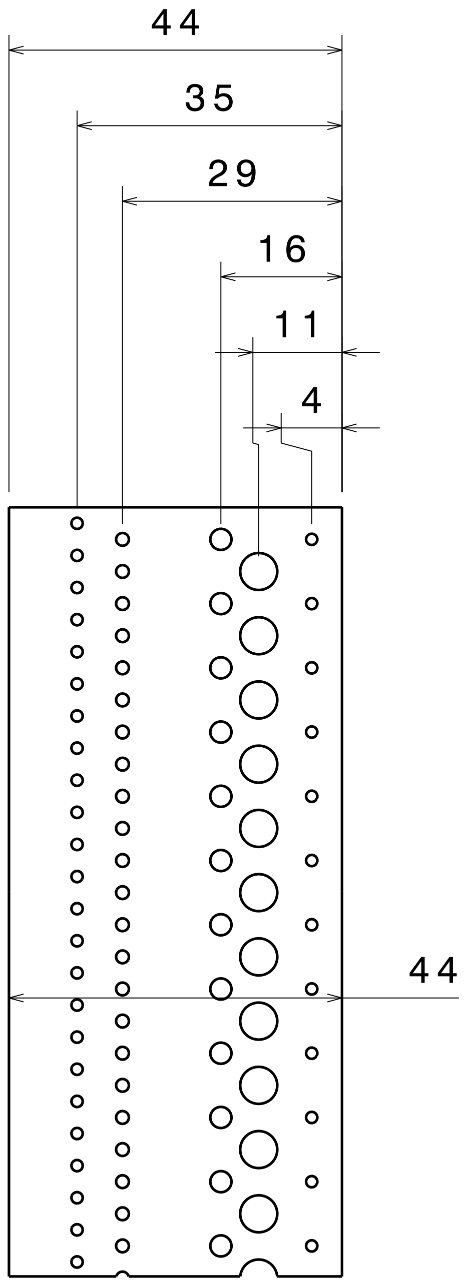
Top view
Scale: 1:1



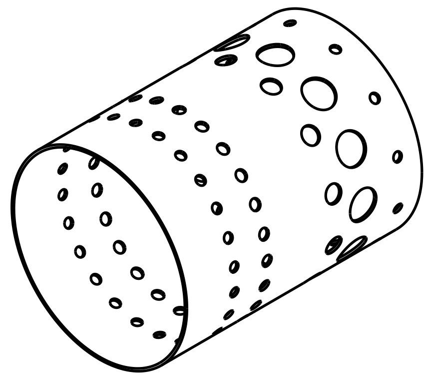
Isometric view
Scale: 1:1

Dimensions in mm

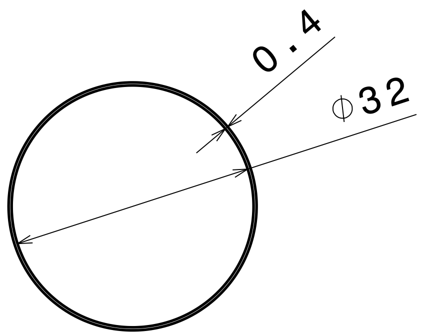
| | |
|---|---|
| Part Number | 021 |
| Part Name | Combustion Chamber Assembly |
| Material | Stainless Steel |
| Author | Thomas Dickinson |




Unfolded view
Scale: 1:1



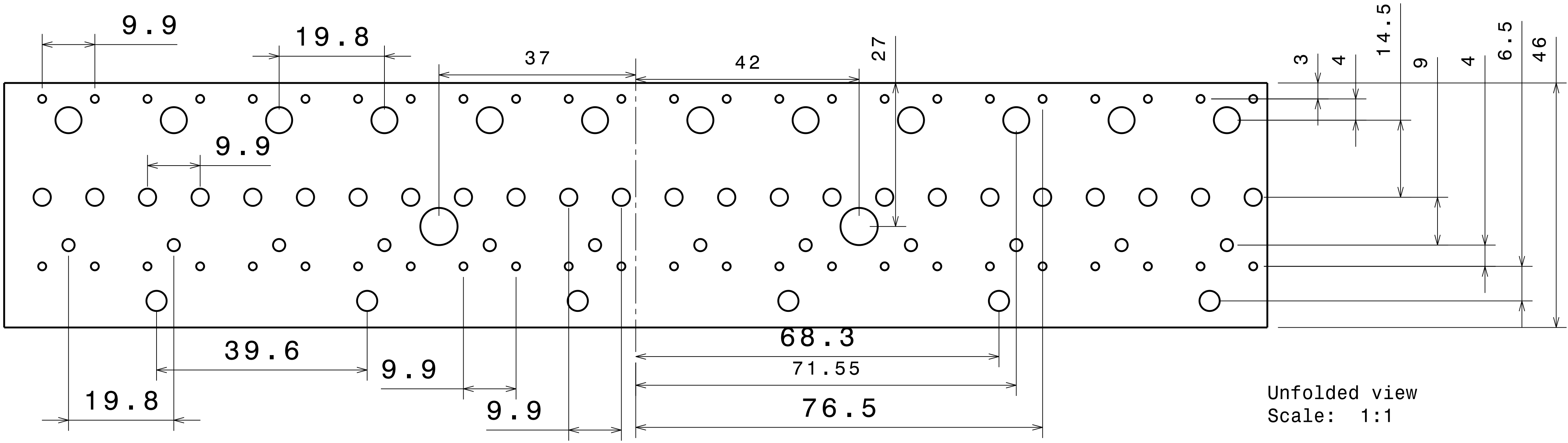
Isometric view
Scale: 1:1



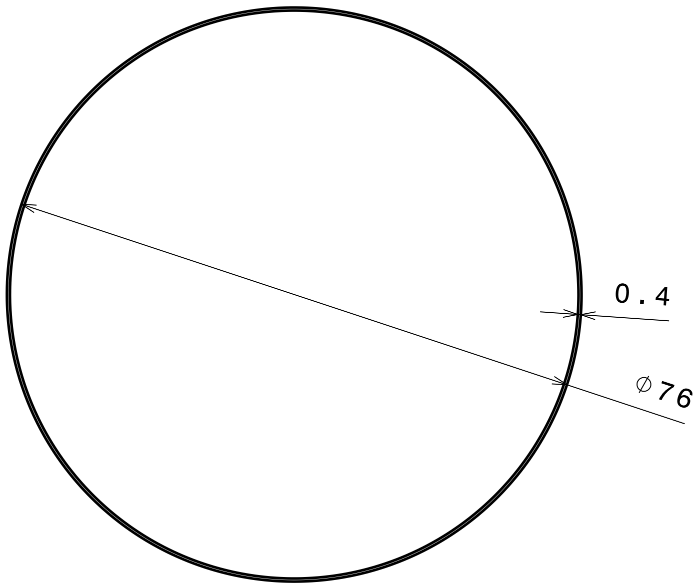

Left view
Scale: 1:1

Dimensions in mm

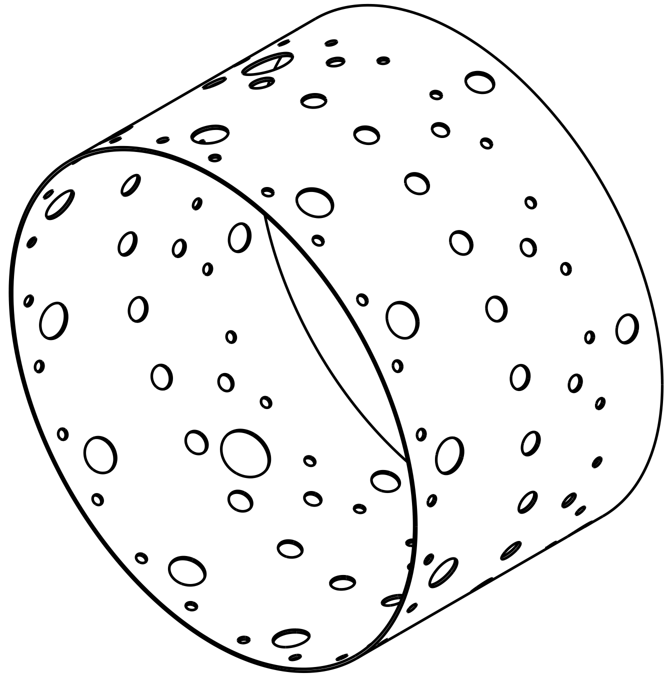
| | |
|---|---|
| Part Number | 022 |
| Part Name | Inner Combustor Wrapper |
| Material | .4mm Stainless Steel Sheet |
| Author | Thomas Dickinson |




Unfolded view
Scale: 1:1



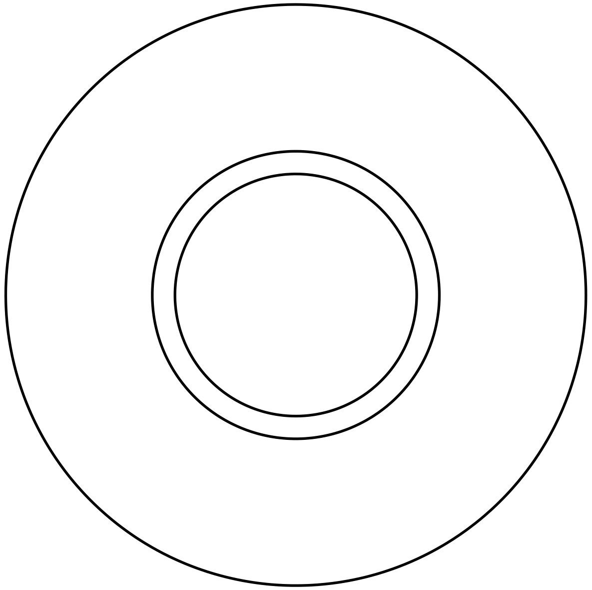

Left view
Scale: 1:1



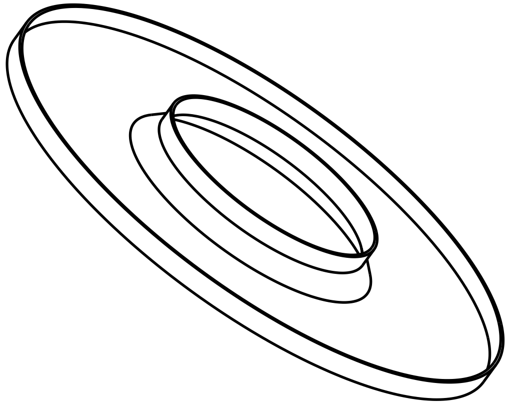
Isometric view
Scale: 1:1

Dimensions in mm

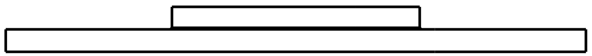
| | |
|---|---|
| Part Number | 023 |
| Part Name | Outer Combustor Wrapper |
| Material | .4mm Stainless Steel Sheet |
| Author | Thomas Dickinson |



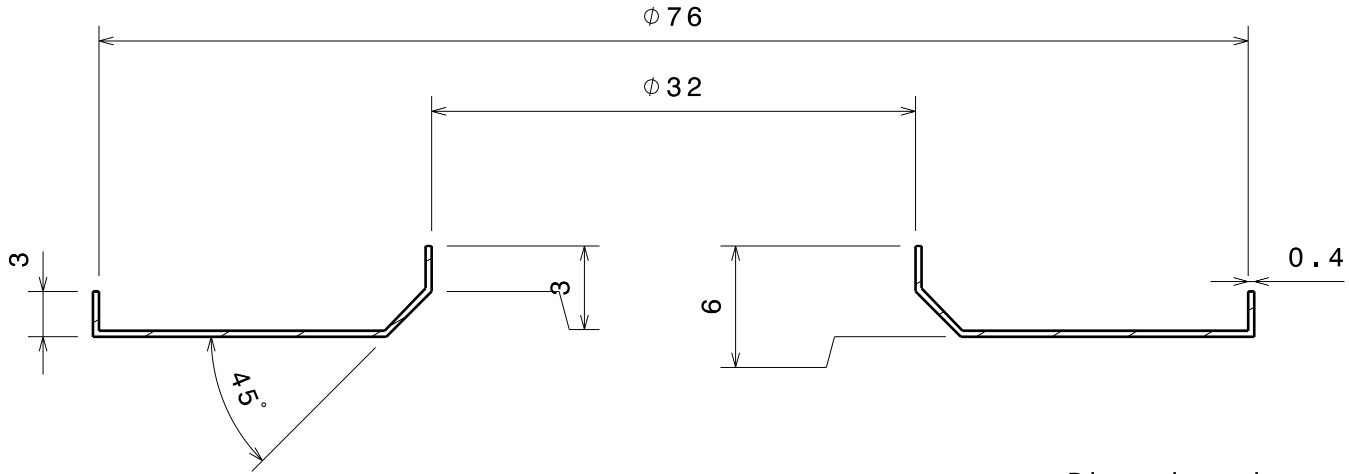
Bottom view
Scale: 1:1



Isometric view
Scale: 1:1



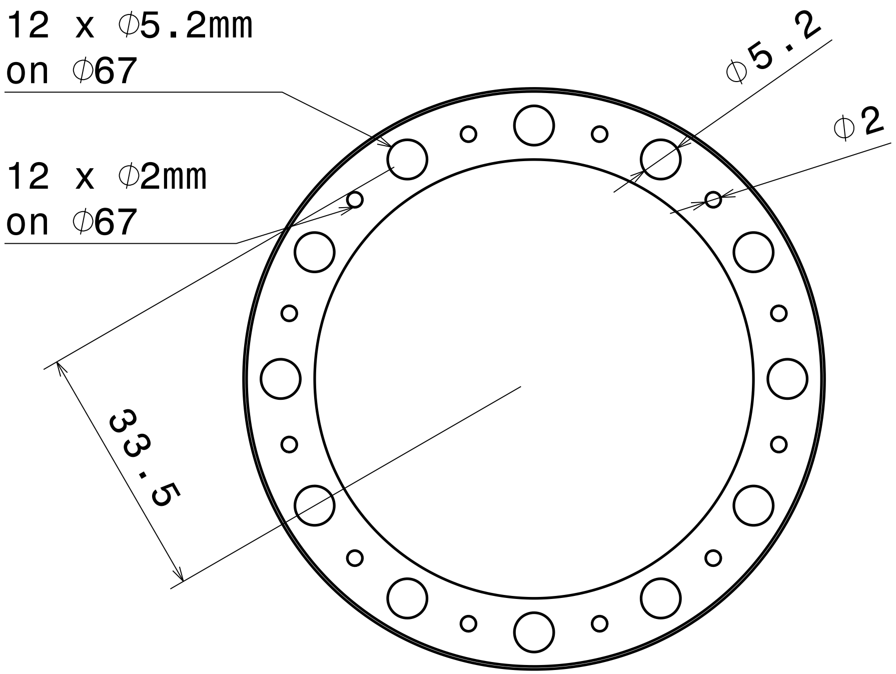
Front view
Scale: 1:1



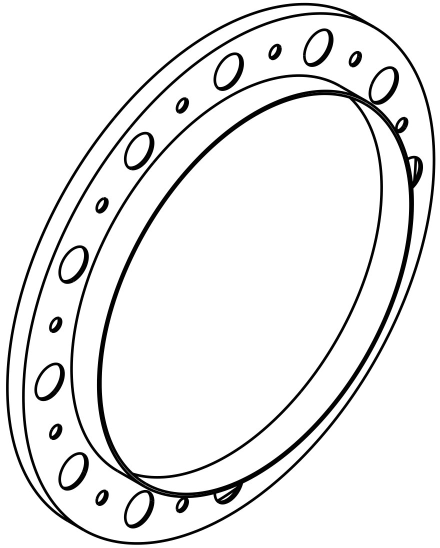

Section cut A-A
Scale: 2:1

Dimensions in mm

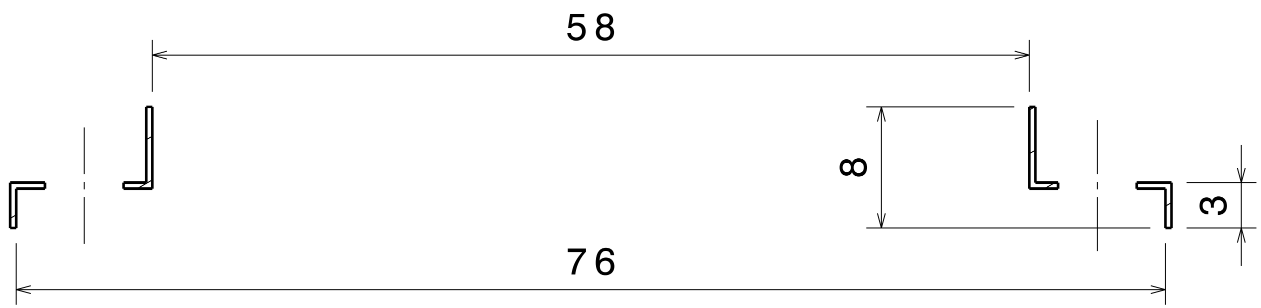
| | |
|---|---|
| Part Number | 024 |
| Part Name | Combustion Chamber Front |
| Material | .4mm Stainless Steel Sheet |
| Author | Thomas Dickinson |




Bottom view
Scale: 1:1



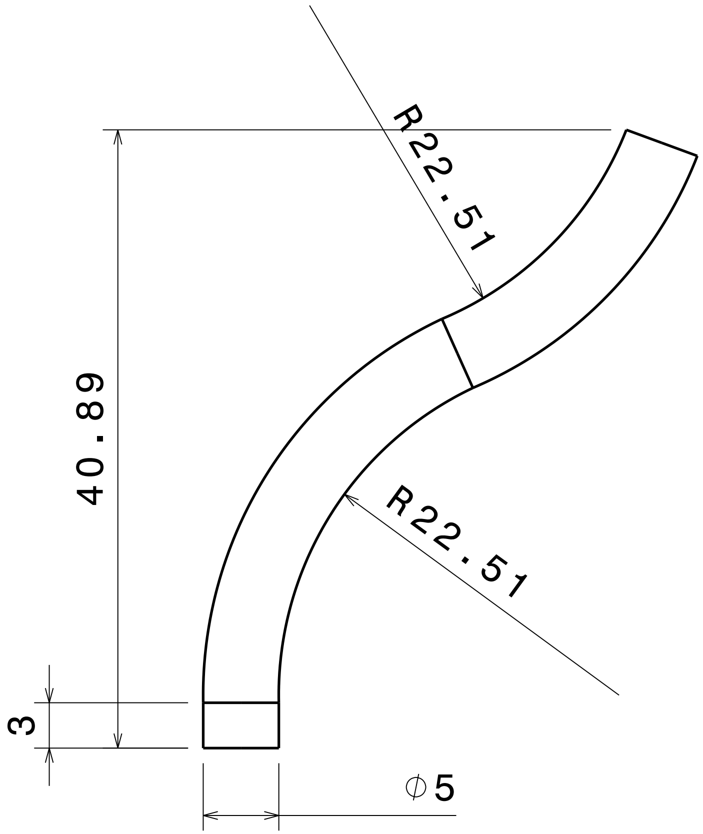
Isometric view
Scale: 1:1



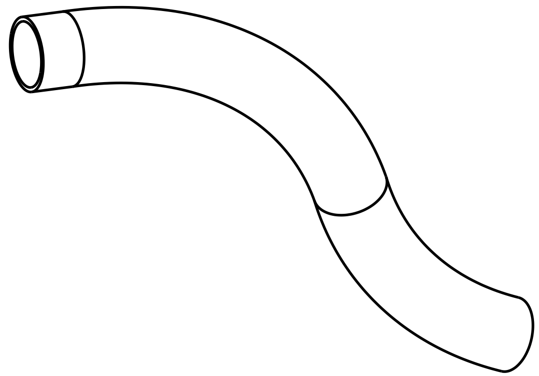

Section cut A-A
Scale: 2:1

Dimensions in mm

| | |
|---|---|
| Part Number | 025 |
| Part Name | Combustor Rear |
| Material | .4mm Stainless Steel Sheet |
| Author | Thomas Dickinson |



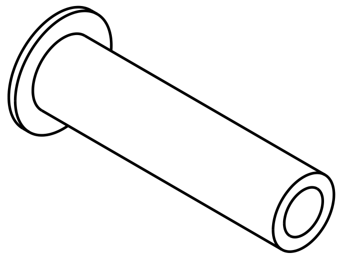

Right view
Scale: 2:1



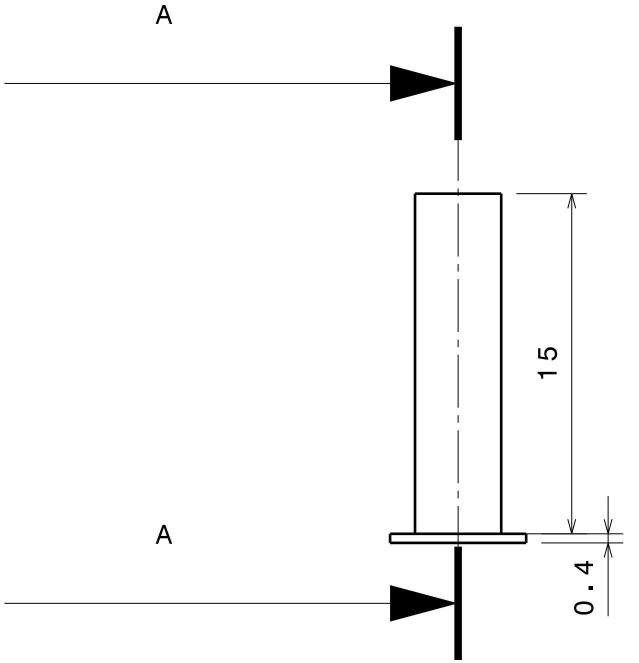
Isometric view
Scale: 2:1

Dimensions in mm

| | |
|---|---|
| Part Number | 026 |
| Part Name | Vapouriser Tube |
| Material | .3mm Stainless Steel Tube |
| Author | Thomas Dickinson |

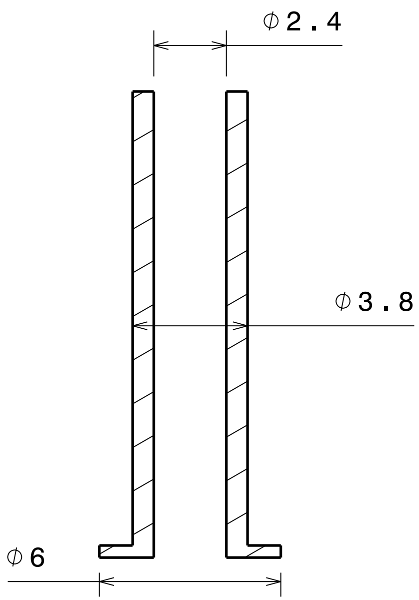


Isometric view
Scale:  3:1




Front view
Scale:  3:1

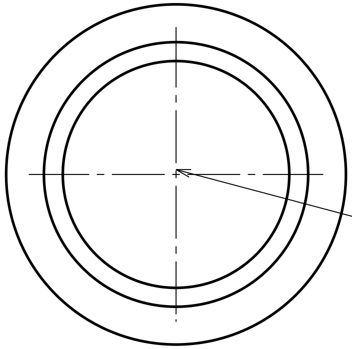
Section cut A-A
Scale:  4:1




| | |
|---|---|
| Part Number | 027 |
| Part Name | Swirl Jet |
| Material | Stainless Steel |
| Author | Thomas Dickinson |

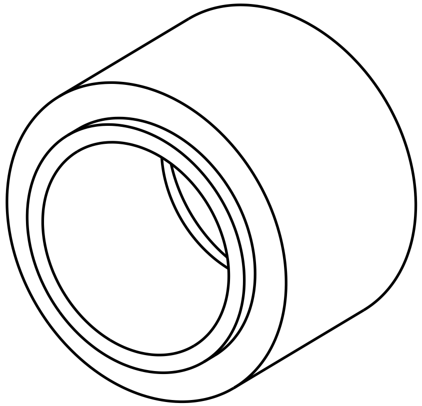
Dimensions in mm

Top view
Scale:  5:1

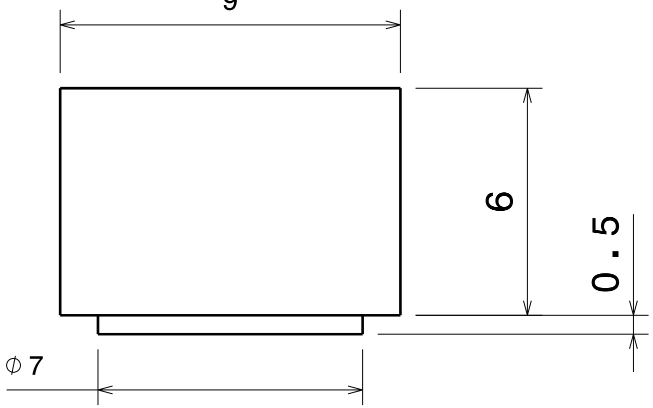


Tap through .25"x 32
TPI to suit glow plug

Isometric view
Scale:  5:1

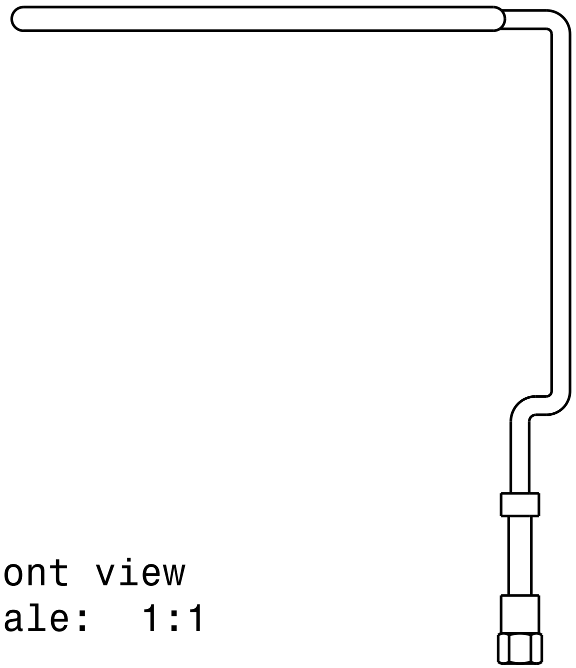


Front view
Scale:  5:1

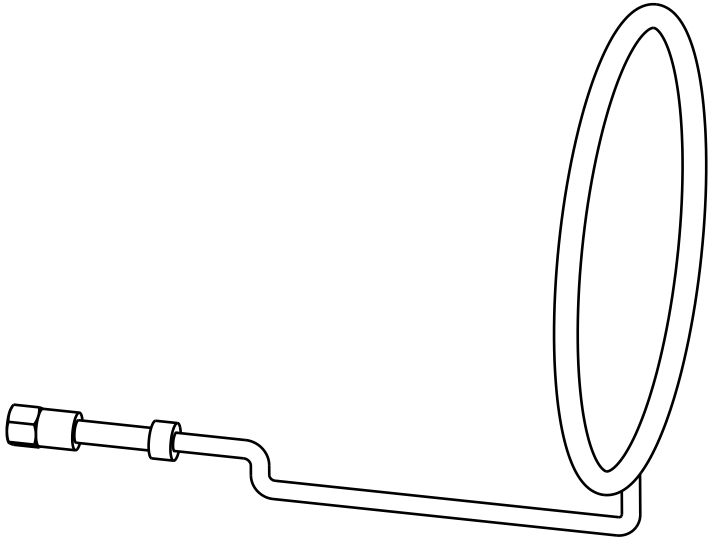



Dimensions in mm

| | |
|---|---|
| Part Number | 028 |
| Part Name | Glow Plug Boss |
| Material | Stainless Steel |
| Author | Thomas Dickinson |



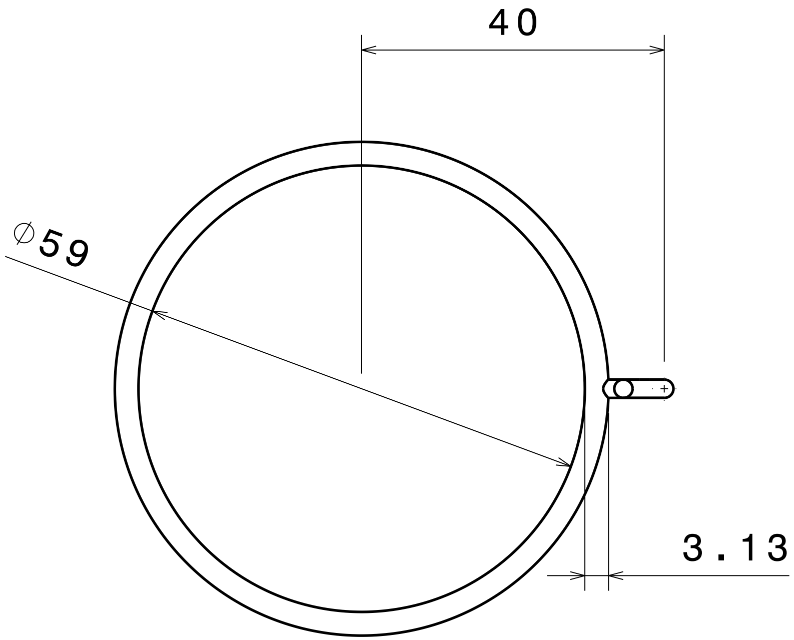
Front view
Scale: 1:1



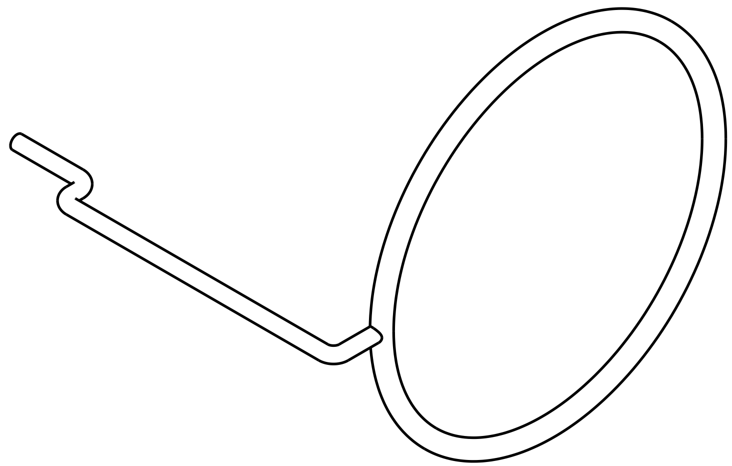
Isometric view
Scale: 1:1

Dimensions in mm

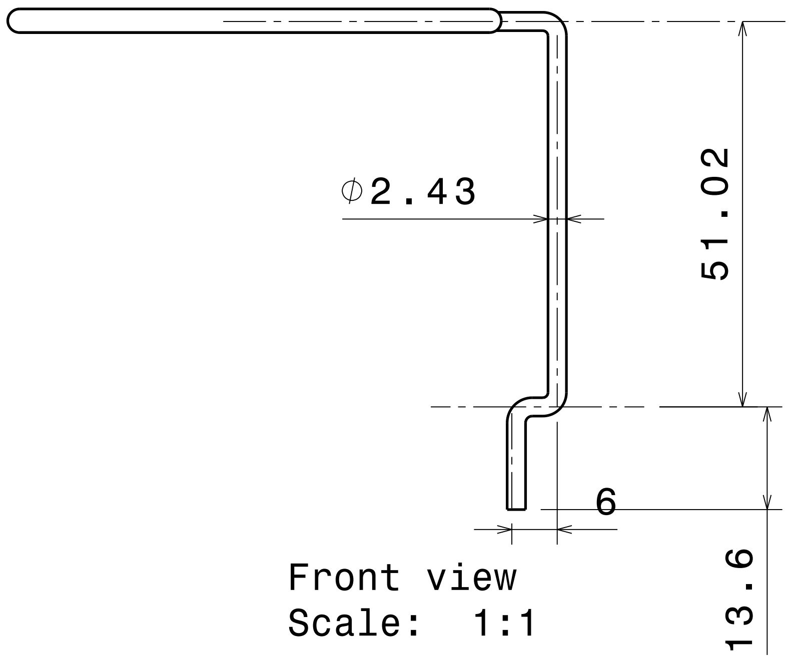
| | |
|---|---|
| Part Number | 029 |
| Part Name | Fuel Pipe Assembly |
| Material | Various |
| Author | Thomas Dickinson |




Bottom view
Scale: 1:1



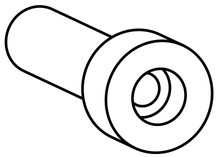
Isometric view
Scale: 1:1



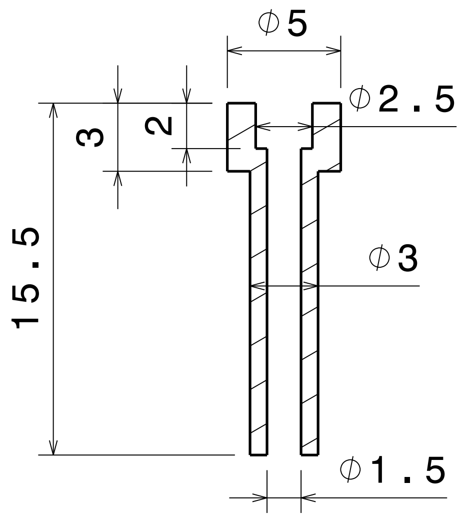

Front view
Scale: 1:1

Dimensions in mm

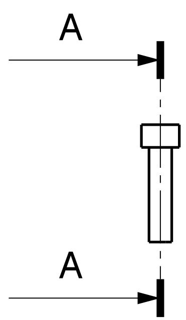
| | |
|---|---|
| Part Number | 030 |
| Part Name | Fuel Pipe |
| Material | Brass Tube |
| Author | Thomas Dickinson |



Isometric view
Scale:  3:1



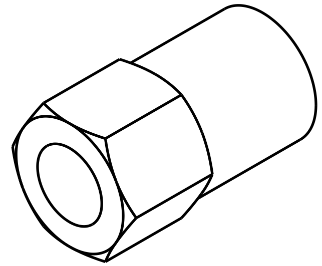

Section cut A-A
Scale:  3:1



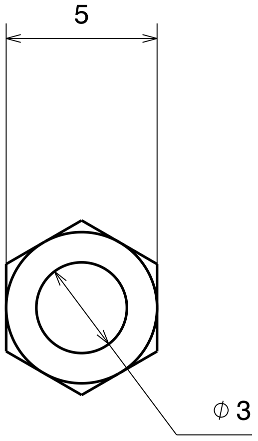

Front view
Scale:  1:1

Dimensions in mm

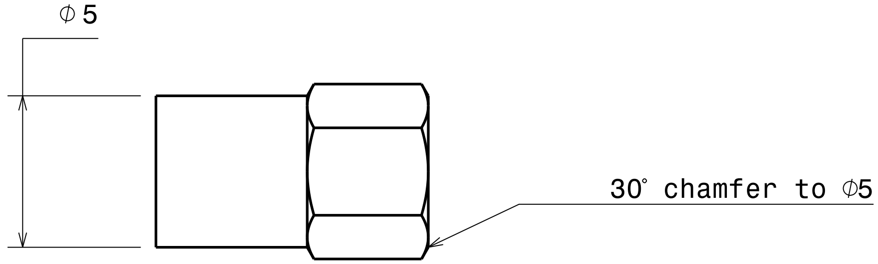
| | |
|---|---|
| Part Number | 031 |
| Part Name | Tube End Fitting |
| Material | Stainless Steel |
| Author | Thomas Dickinson |



Isometric view
Scale:  4:1



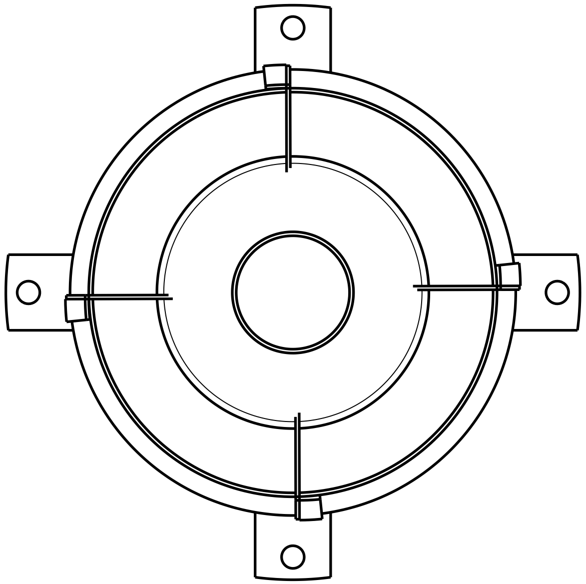

Right view
Scale:  4:1



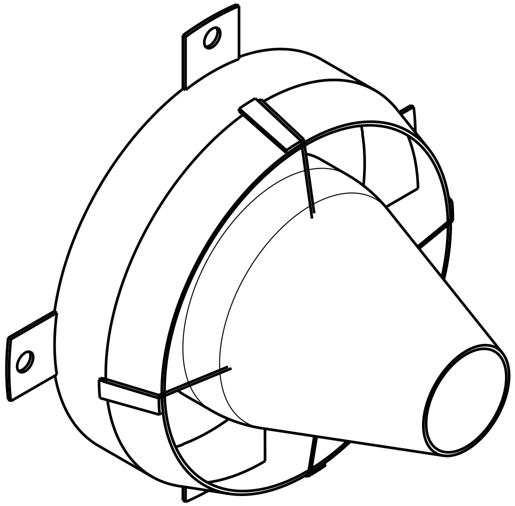

Front view
Scale:  4:1

Dimensions in mm

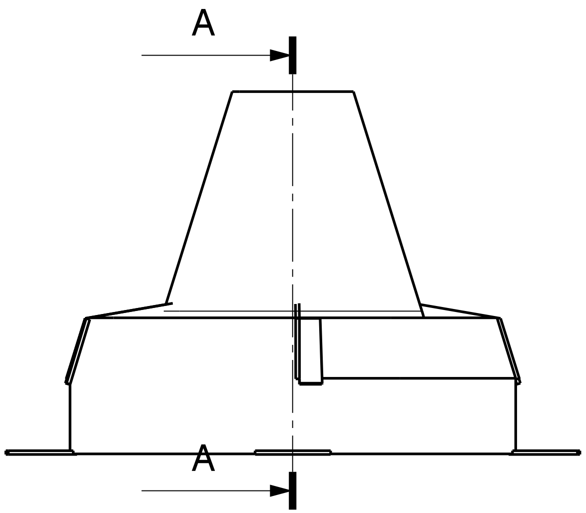
| | |
|---|---|
| Part Number | 032 |
| Part Name | Adaptor |
| Material | Brass |
| Author | Thomas Dickinson |



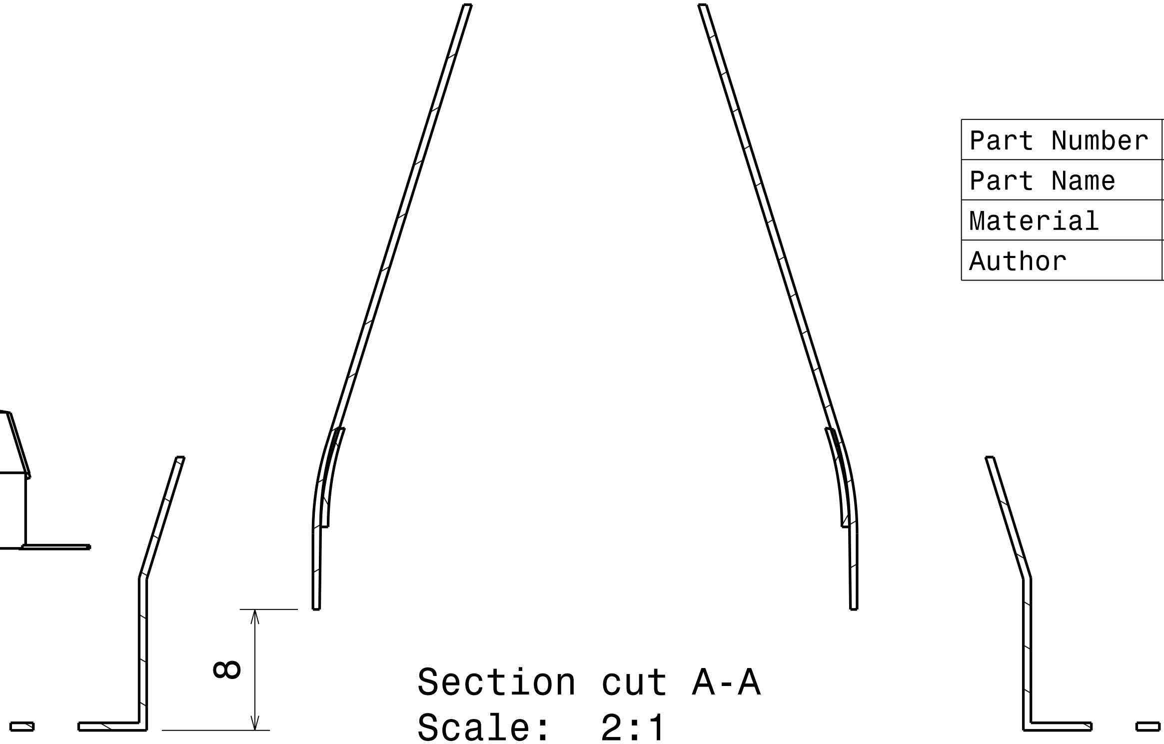
Top view
Scale: 1:1



Isometric view
Scale: 1:1




Left view
Scale: 1:1

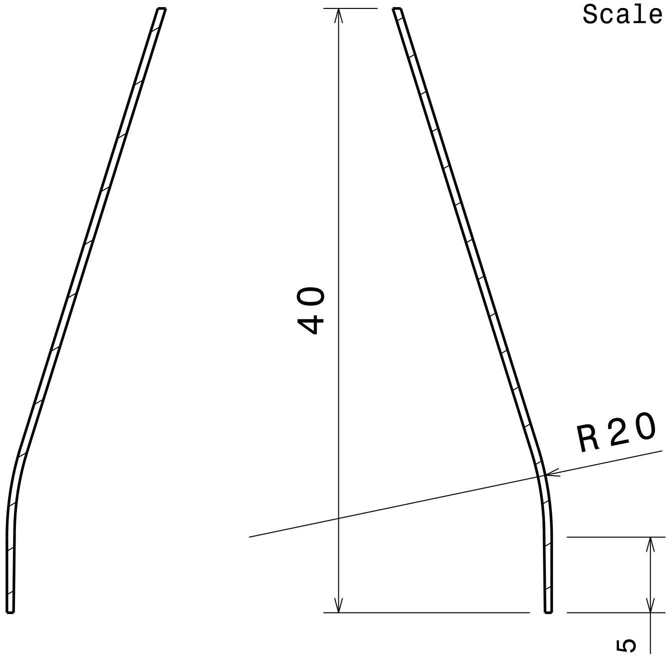



Section cut A-A
Scale: 2:1

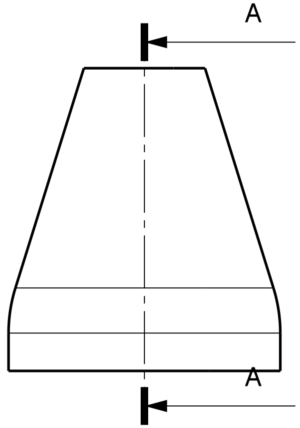
Dimensions in mm

| | |
|---|---|
| Part Number | 033 |
| Part Name | Cone Assembly |
| Material | .5mm Stainless Steel Sheet |
| Author | Thomas Dickinson |

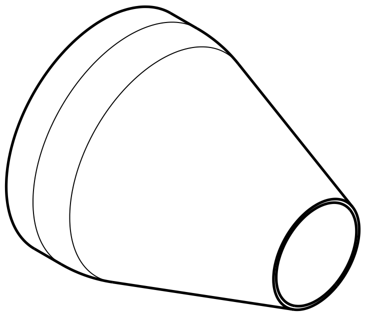
Section cut A-A
Scale: 2:1



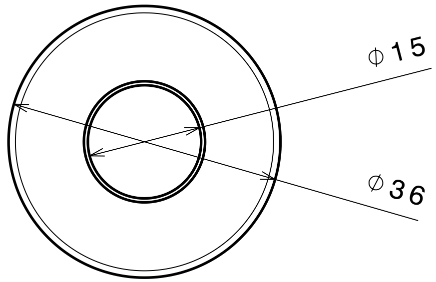

Front view
Scale: 1:1




Isometric view
Scale: 1:1

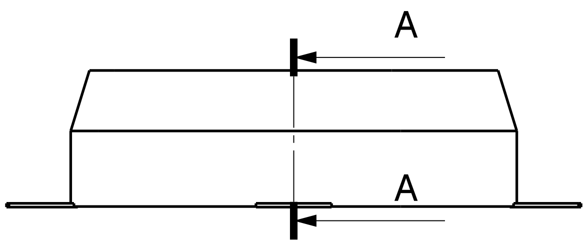


Top view
Scale: 1:1

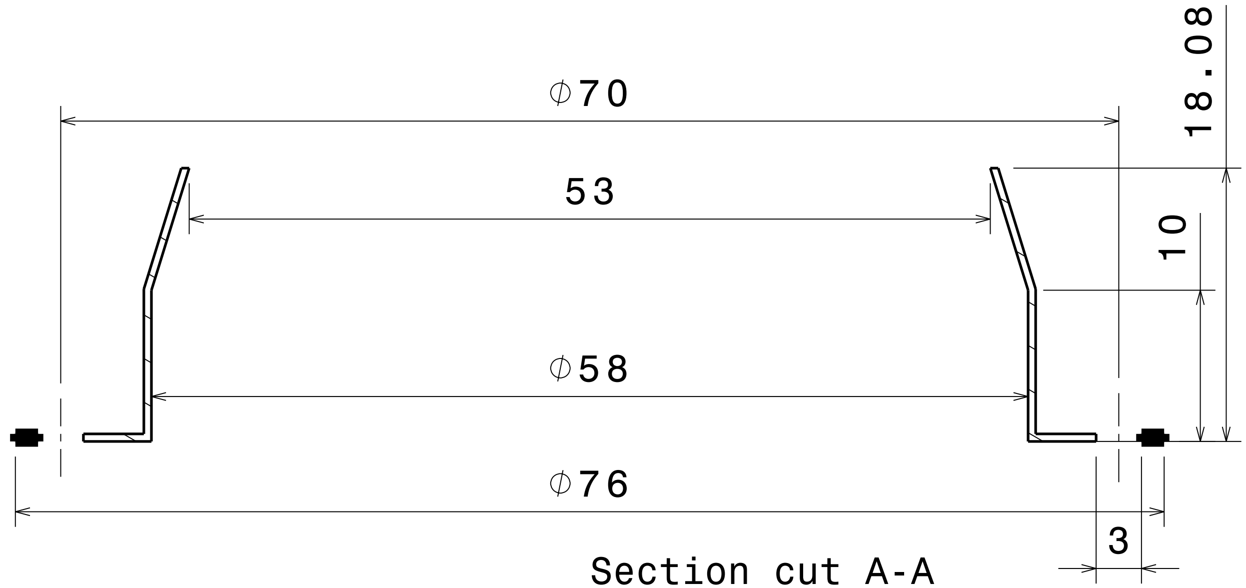



Dimensions in mm

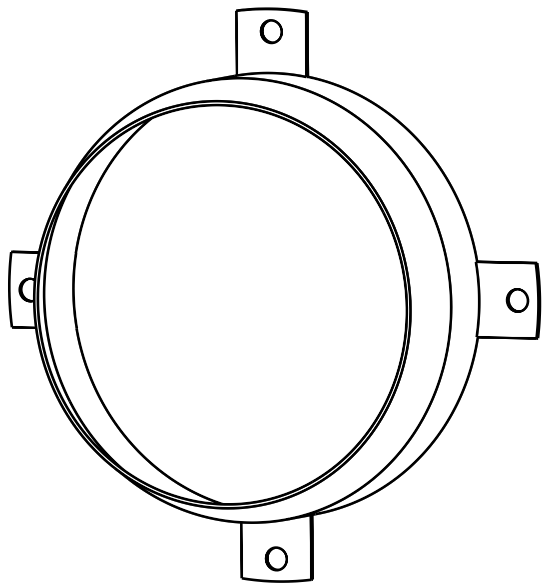
| | |
|---|---|
| Part Number | 034 |
| Part Name | Inner Cone |
| Material | .5mm Stainless Steel Sheet |
| Author | Thomas Dickinson |




Front view
Scale: 1:1



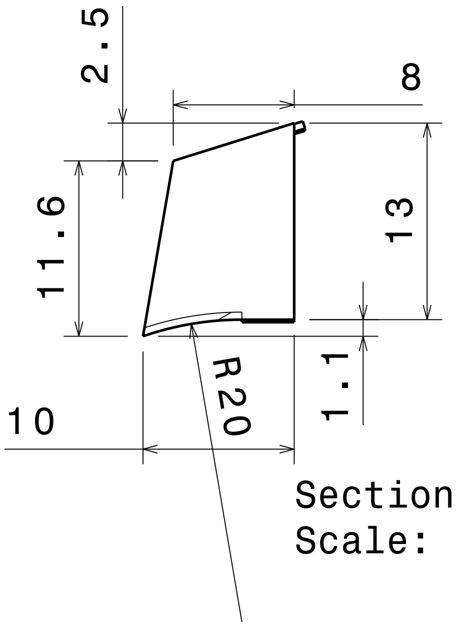

Section cut A-A
Scale: 2:1



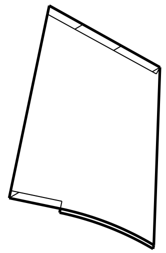
Isometric view
Scale: 1:1

Dimensions in mm

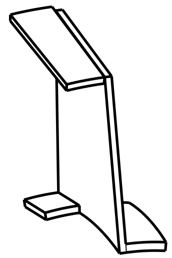
| | |
|---|---|
| Part Number | 035 |
| Part Name | Outer Cone |
| Material | .5mm Stainless Steel Sheet |
| Author | Thomas Dickinson |



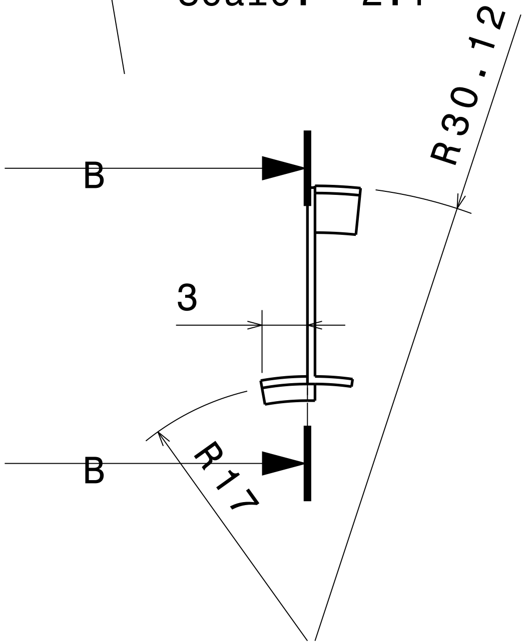

Section view B-B
Scale:  2:1



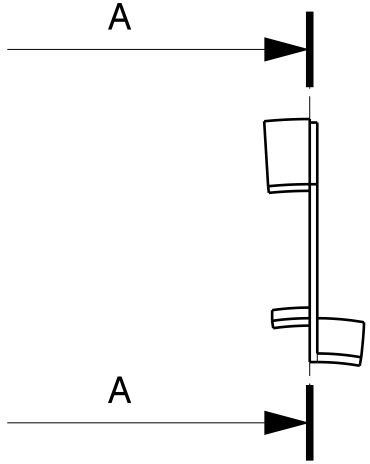
Section view A-A
Scale:  2:1



Isometric view
Scale:  2:1




Rear View
Scale:  2:1

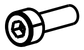



Front view
Scale:  2:1

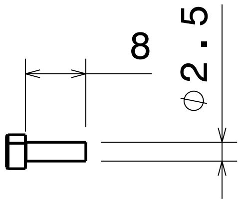
Dimensions in mm

| | |
|---|---|
| Part Number | 036 |
| Part Name | Outlet Vane |
| Material | .5mm Stainless Steel Sheet |
| Author | Thomas Dickinson |

Part 037 M2.5x8

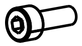


Isometric view
Scale: 1:1

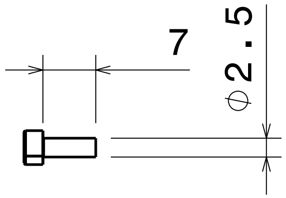



Side view
Scale: 1:1

Part 038 M2.5x7



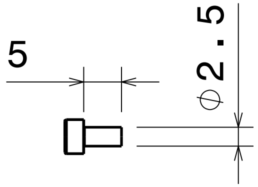
Isometric view
Scale: 1:1




Side view
Scale: 1:1

Part 039 M2.5x5

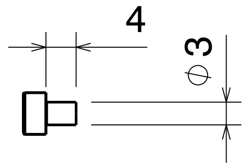
Isometric view
Scale: 1:1




Side view
Scale: 1:1

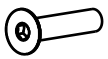
Part 040 M3x4

Isometric view
Scale: 1:1

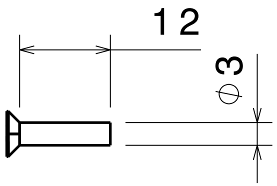



Side view
Scale: 1:1

Part 041
Countersunk M3x12



Isometric view
Scale: 1:1

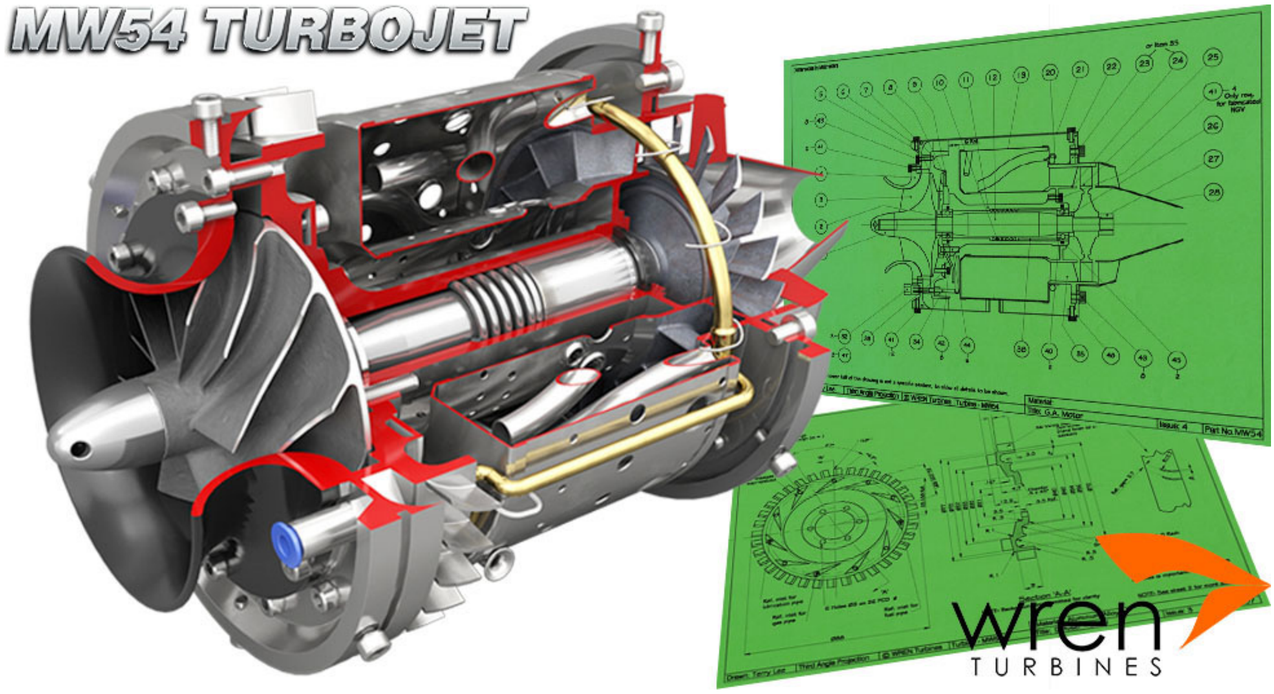



Side view
Scale: 1:1

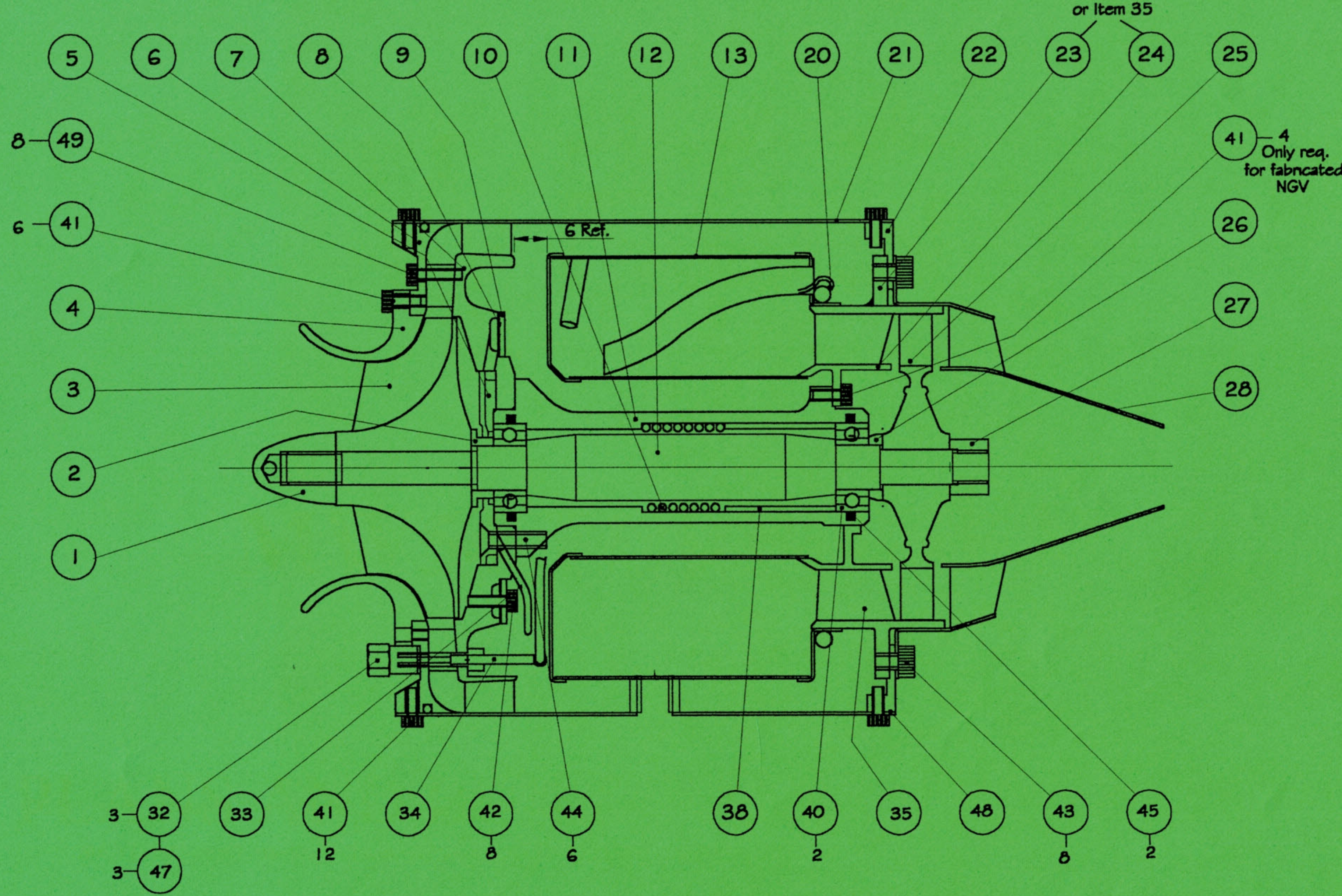
Dimensions in mm

| | |
|---|---|
| Part Number | 037-041 |
| Part Name | Cap Screw & Csk. Screw |
| Material | Stainless Steel |
| Author | Thomas Dickinson |

# Appendix III - Wren Turbine 2D Plans



Dimensions in Millimeters




Note: The lower half of the drawing is not a specific section, to allow all details to be shown.

| Material: | | | | | | |
|---|---|---|---|---|---|---|
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: G.A. Motor | Issue: 4 | Part No.MW54 |

| Item No | Description | No Off | Material | Issue | Remarks |
|---|---|---|---|---|---|
| 1 | Compressor Nut | 1 | Aluminium alloy | 1 | |
| 2 | Front Spacer | 1 | Mild steel | 1 | |
| 3 | Compressor | 1 | Garrett (Part No.446335-10) | 5 | Standard compressor modified |
| 4 | Intake | 1 | Nylon | 4 | Drg. now to suit comp. 09 or -10 |
| 5 | Shaft Seal | 1 | Aluminium alloy | 2 | |
| 6 | Case Front | 1 | Aluminium alloy | 5 | 'Chf. not required' note added |
| 7 | Diffuser | 1 | Aluminium alloy | 3 | Sheet 2: issue 3 |
| 8 | Filter | 1 | Stainless steel | 2 | |
| 9 | Filter Cover | 1 | Aluminium alloy | 2 | |
| 10 | Spring | 1 | Spring steel | 2 | |
| 11 | Tunnel | 1 | Aluminium alloy | 3 | |
| 12 | Shaft | 1 | En 24T | 2 | |
| 13 | Combustion Chamber S/A | 1 | Comprising items 14 - 19 | 4 | |
| 14 | Combustion Chamber Front | 1 | Stainless steel | 1 | |
| 15 | Glow Plug Boss | 2 | Stainless steel | 1 | |
| 16 | Combustor Wrapper Inner | 1 | Stainless steel | 2 | |
| 17 | Combustor Wrapper Outer | 1 | Stainless steel | 4 | |
| 18 | Vaporiser Tube | 6 | Stainless steel | 3 | |
| 19 | Combustion Chamber Rear | 1 | Stainless steel | 2 | |
| 20 | Fuel Pipe Assy. | 1 | Brass | 3 | |
| 21 | Case Outer | 1 | Stainless steel | 3 | |
| 22 | Case Rear | 1 | Mild steel | 3 | |
| 23 | NGV Outer | 1 | Stainless steel | 1 | Not required if cast version is used - item 35 |
| 24 | NGV Inner | 1 | Stainless steel | 2 | |
| 25 | Turbine Wheel | 1 | Inconel | 1 | |
| 26 | Rear Spacer | 1 | Mild steel | 1 | |
| 27 | Turbine Nut | 1 | Stainless steel | 1 | |
| 28 | Exhaust Cone Assy. | 1 | Comprising items 29 - 31 | 2 | |
| 29 | Cone Outer | 1 | Stainless steel | 1 | |
| 30 | Cone Inner | 1 | Stainless steel | 1 | |

| | |
|---|---|
| Issue: 3 | Item List for MW54<br>Sht.1 |

| Item No | Description | No Off | Material | Issue | Remarks |
|---|---|---|---|---|---|
| 31 | Outlet Vane | 4 | Stainless steel | 2 | |
| 32 | Adaptor | 3 | Brass | 2 | |
| 33 | Lubrication Pipe | 1 | Brass | 2 | |
| 34 | Gas Pipe | 1 | Brass/Stainless steel | 2 | |
| 35 | Cast NGV | 1 | | 2 | Items 23/24 not req |
| 36 | Tube End Fitting | 3 | Stainless steel | 3 | |
| 37 | Templates | | | 2 | |
| 38 | Preload Tube | 1 | Mild steel | 2 | |
| 39 | Swirl Jet | 6 | Stainless steel | 2 | |
| 40 | Ball Race | 2 | GRW 688 - Ceramic | | |
| 41 | Cap screw M2.5 x 5 | 22* | Stainless steel | | *18 if cast NGV |
| 42 | Cap screw M2.5 x 7 | 8 | Stainless steel | | |
| 43 | Cap screw M3 x 4 | 8 | Stainless steel | | |
| 44 | Skt hd. Csk. Screw M3 x 12 | 6 | Stainless steel | | |
| 45 | 'O' ring | 2 | 16 x 1.5 | | Viton |
| 46 | | | | | |
| 47 | Seal | 3 | Fibre washer 3.0 bore | | |
| 48 | Sealant | | High temp Silicone | | |
| 49 | Cap screw M2.5 x 8 | 8 | Stainless steel | | |
| 50 | 'O' ring cord | | Dia. 1.5 mm section | | 275 long |
| | | | | | |
| | General arrangement | | | 5 | |

**NOTES**

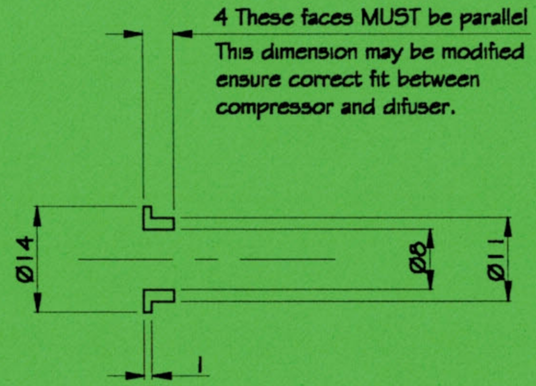
a) Some items have an indication **' TOP '.** It is suggested you mark this position on the item during manufacture.

b) Some groups of holes are marked with the symbol **#** , this indicates that the relative position between these groups is important.

c) All drawings are full size, although some have enlarged views.

d) All dimensions are **nominal,** this means that you should allow the appropriate clearances where parts are fitted together. Full engineering tolerances would only complicate the manufacture.

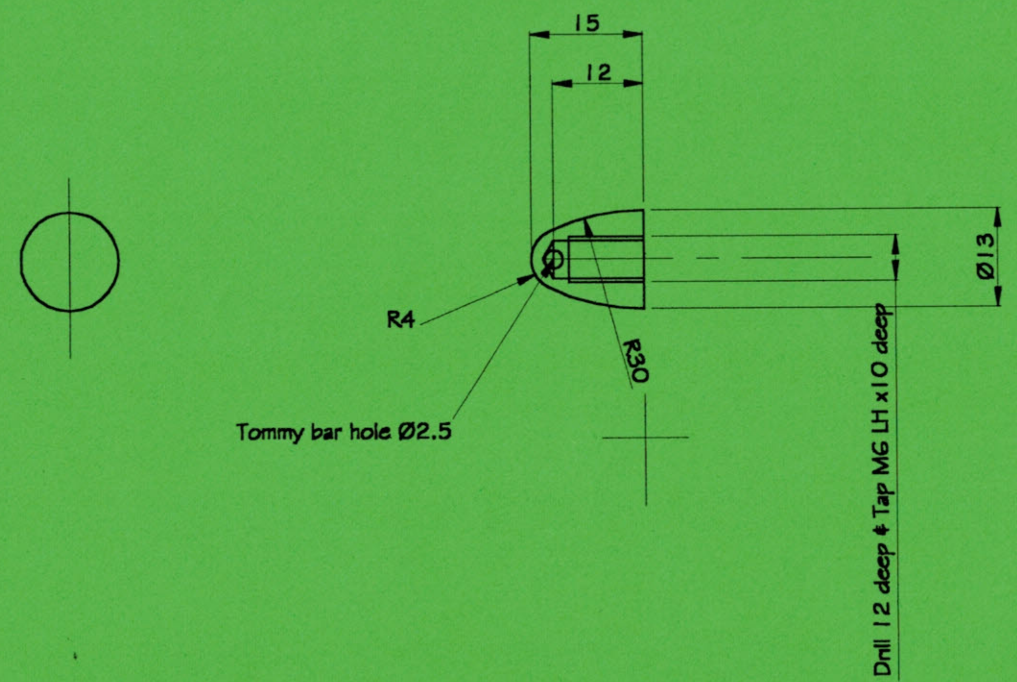
Dimensions in Millimeters




Actual Size

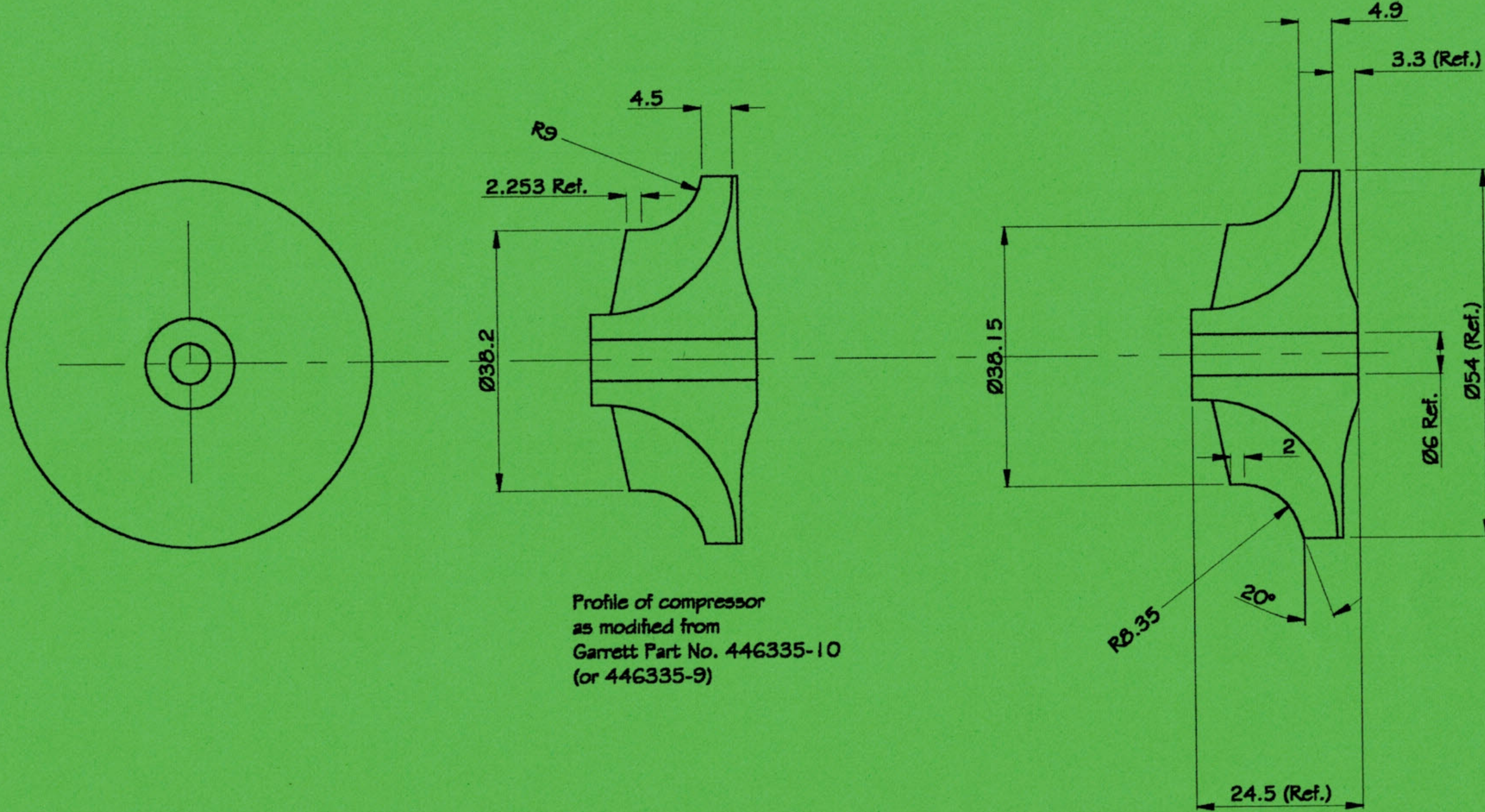
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Material: Mild Steel | | |
|---|---|---|---|---|---|---|
| | | | | Title: Front Spacer | Issue: 1 | Part No. 002 |

Dimensions in Millimeters




| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Aluminium alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Compressor Nut | Issue: 1 | Part No. 001 |

Dimensions in Millimeters




Profile of compressor
as modified from
Garrett Part No. 446335-10
(or 446335-9)

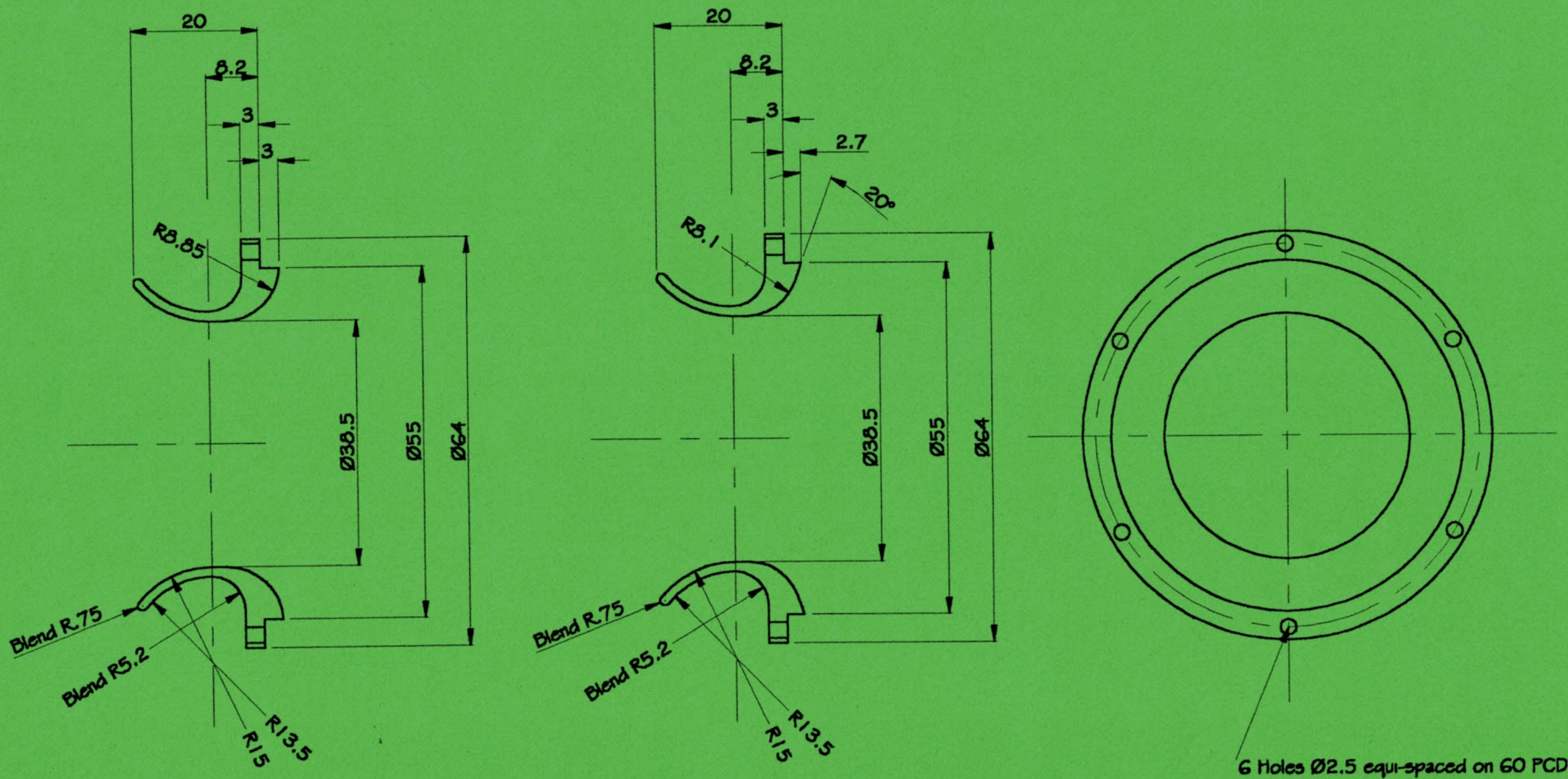
## Please Note:

Although the engine will run using the compressor part No. 446335-9,
it will accelerate much better using the modified form as shown above.
The '-10' compressor is also less expensive.

Profile of standard compressor:
Garrett Part No. 446335-9

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Aluminium Alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Compressor | Issue: 5 | Part No. 003 |

Dimensions in Millimeters

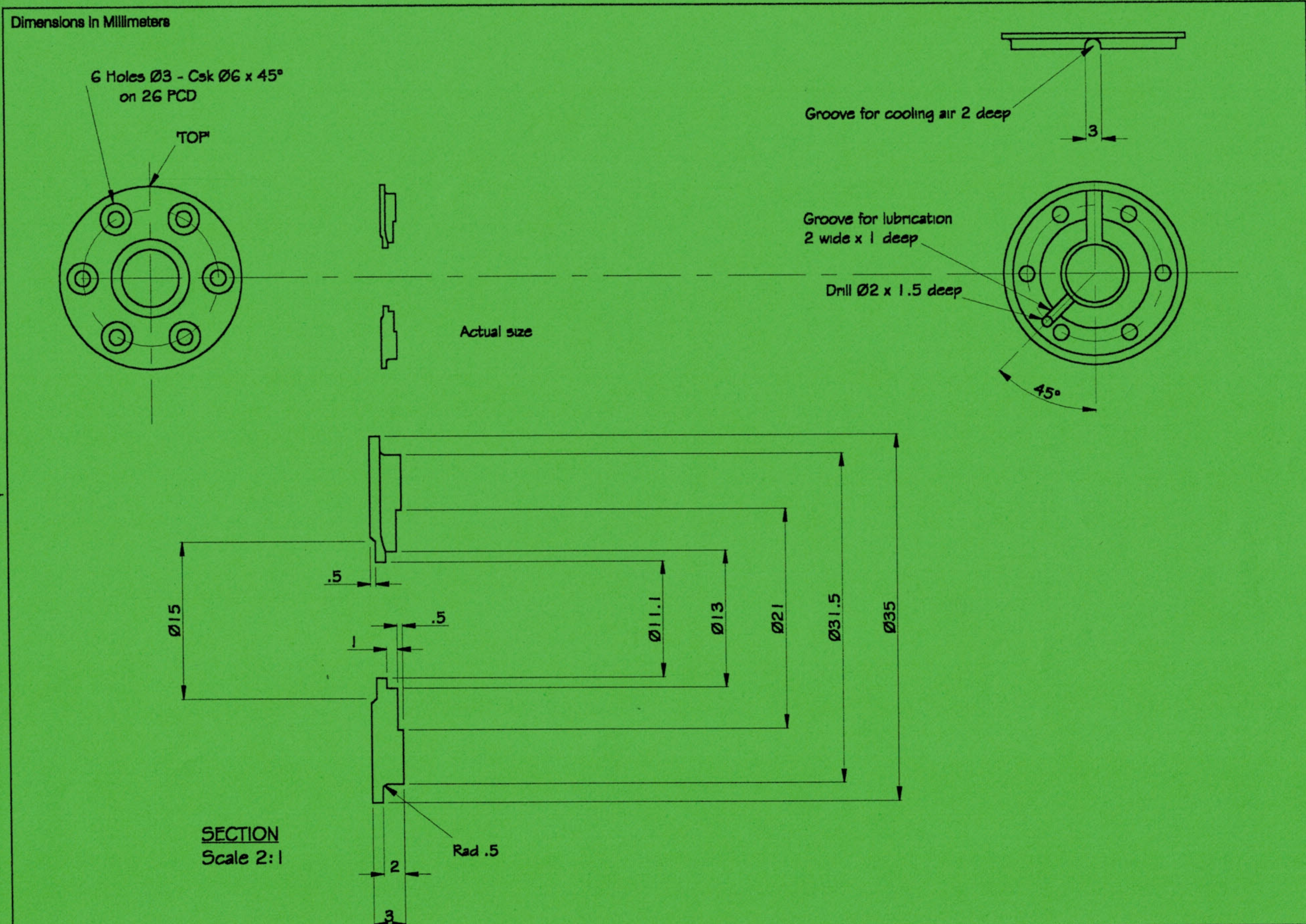



Profile to suit modified compressor

Profile to suit standard compressor
Part No. 446335-9

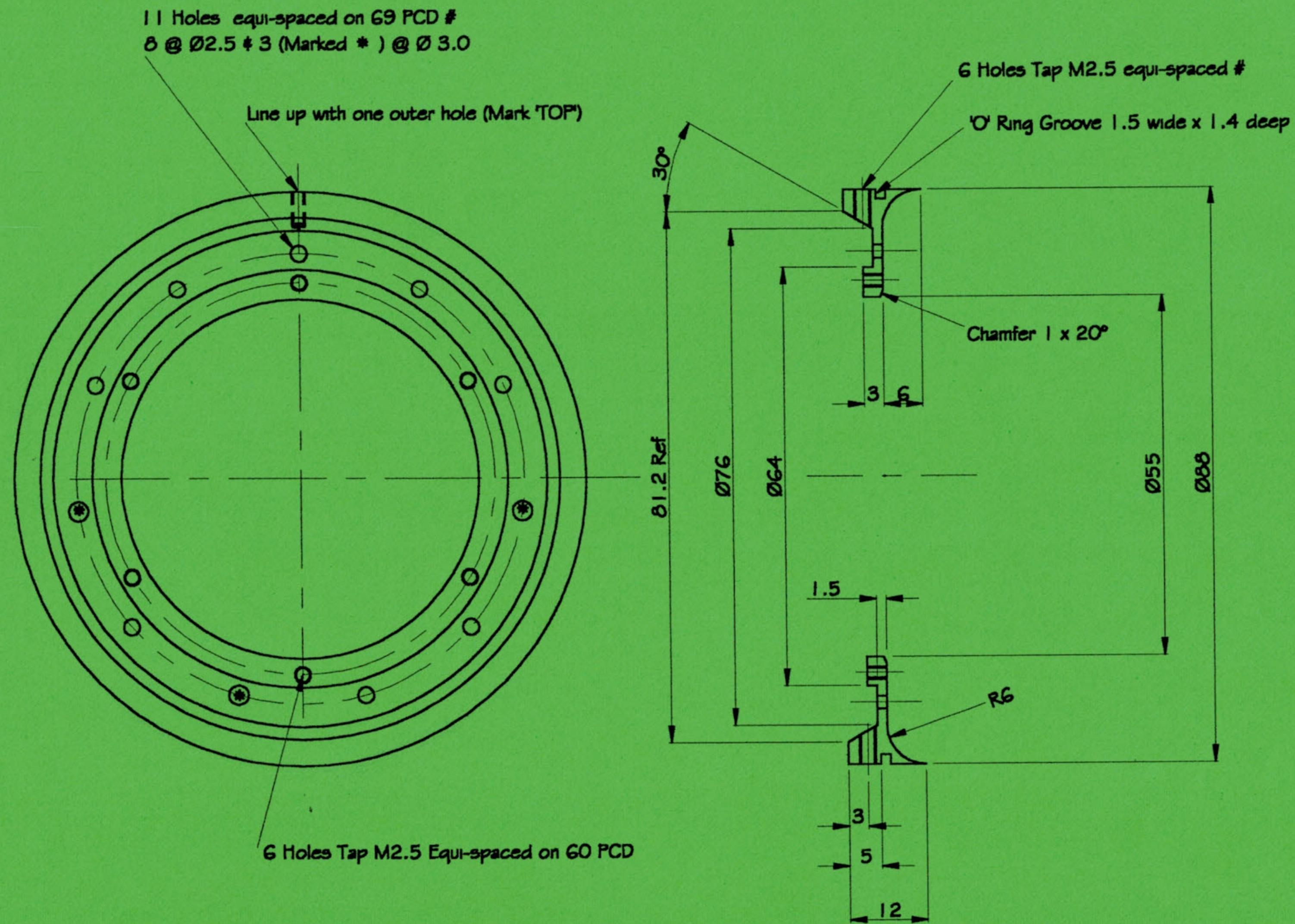
Material: Nylon

Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Intake | Issue: 4 | Part No. 004




| | | | | | |
|---|---|---|---|---|---|
| | | | Material: Aluminium alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Shaft Seal | Issue: 2 | Part No. 005 |

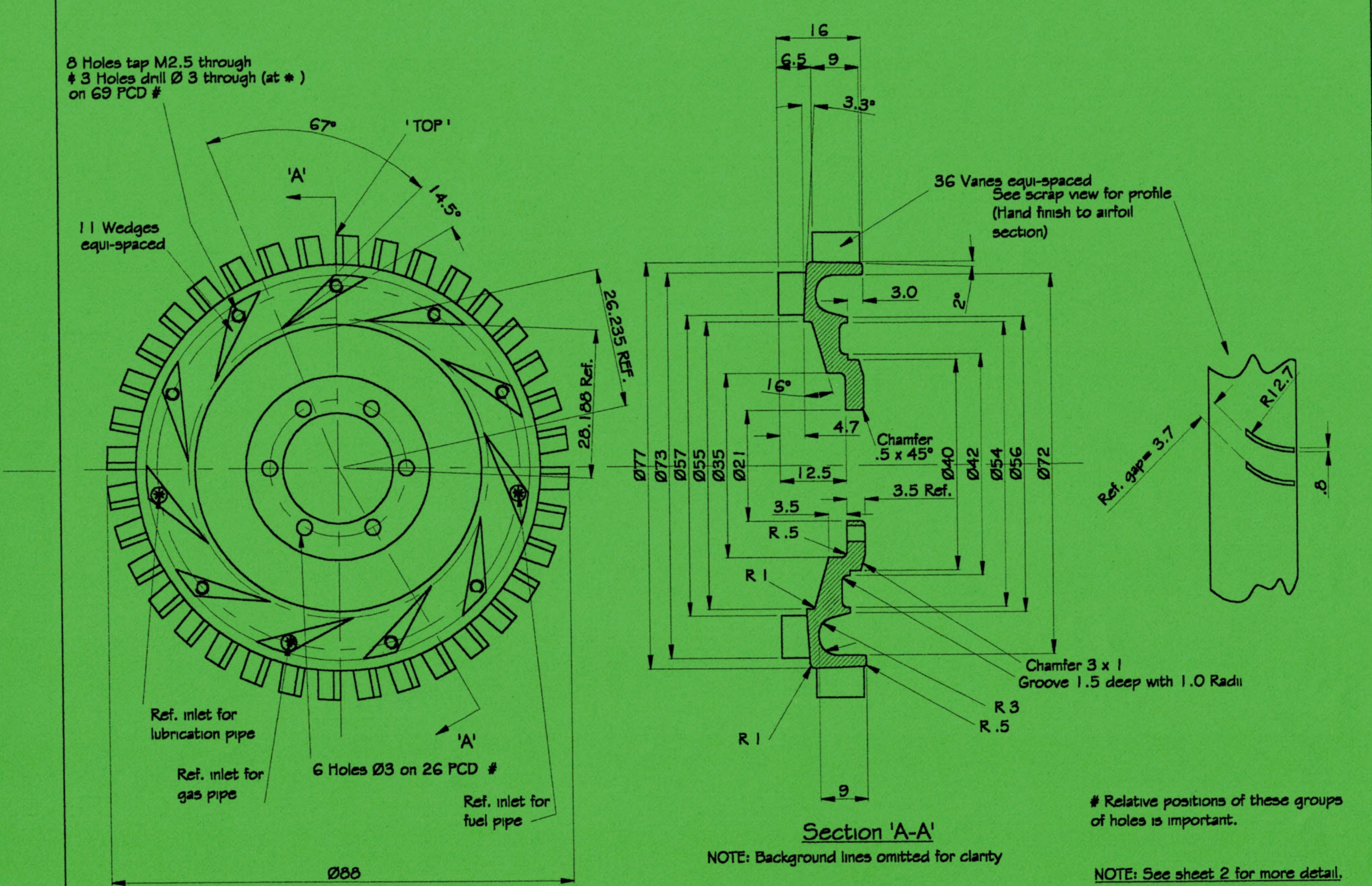
Dimensions in Millimeters




# Note! relative positions of holes marked thus is important.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Aluminium alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Case Front | Issue: 4 | Part No. 006 |

Dimensions in Millimetres




Section 'A-A'

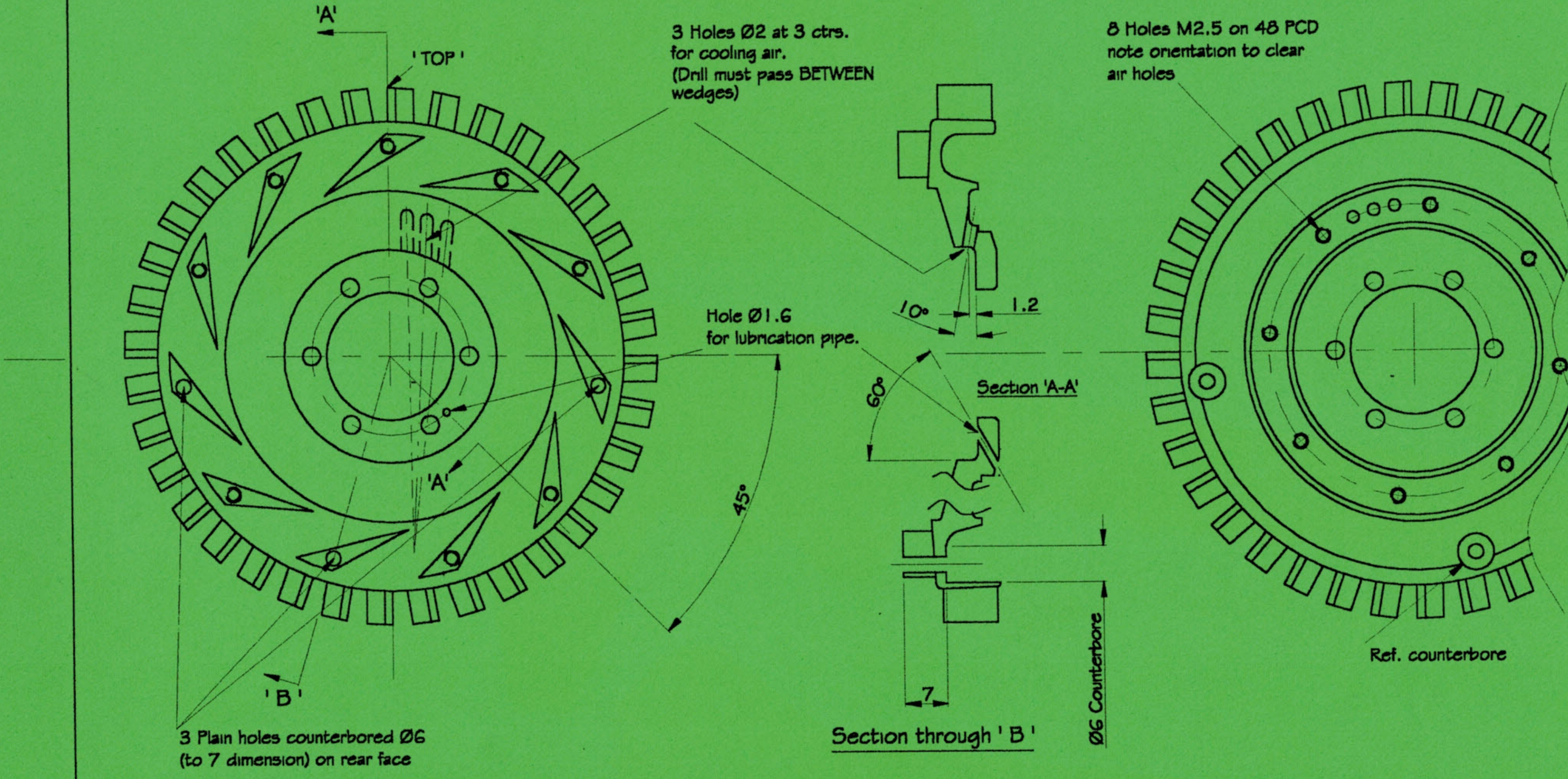
NOTE: Background lines omitted for clarity

# Relative positions of these groups of holes is important.

NOTE: See sheet 2 for more detail.

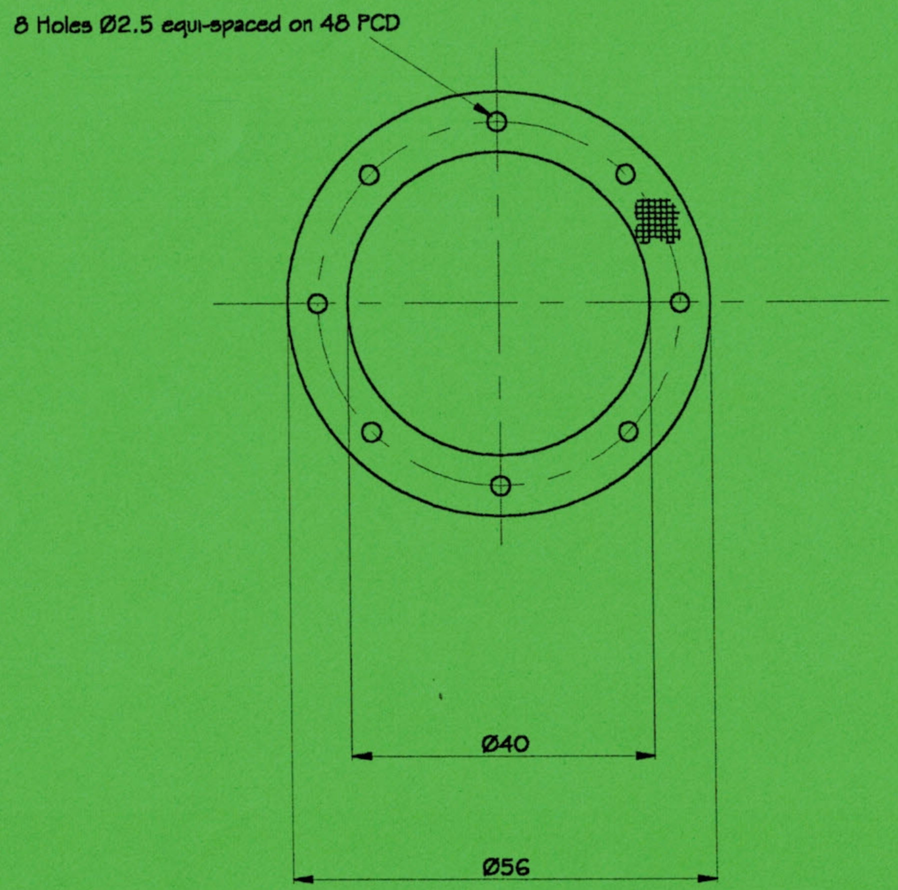
| | | | | | |
|---|---|---|---|---|---|
| | | | Material: Aluminium Alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Diffuser - Sht. 1 | Issue: 3 | Part No. 007 |

Dimensions in Millimetres




| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Aluminium Alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Diffuser - Sht. 2 | Issue: 3 | Part No. 007 |

Dimensions in Millimeters




Suggested method of manufacture

Affix mesh to filter cover using super glue taking care not to block the mesh in the area of the intake holes.
Cut round edges using scissors or knife.
Punch 2mm fixing holes.

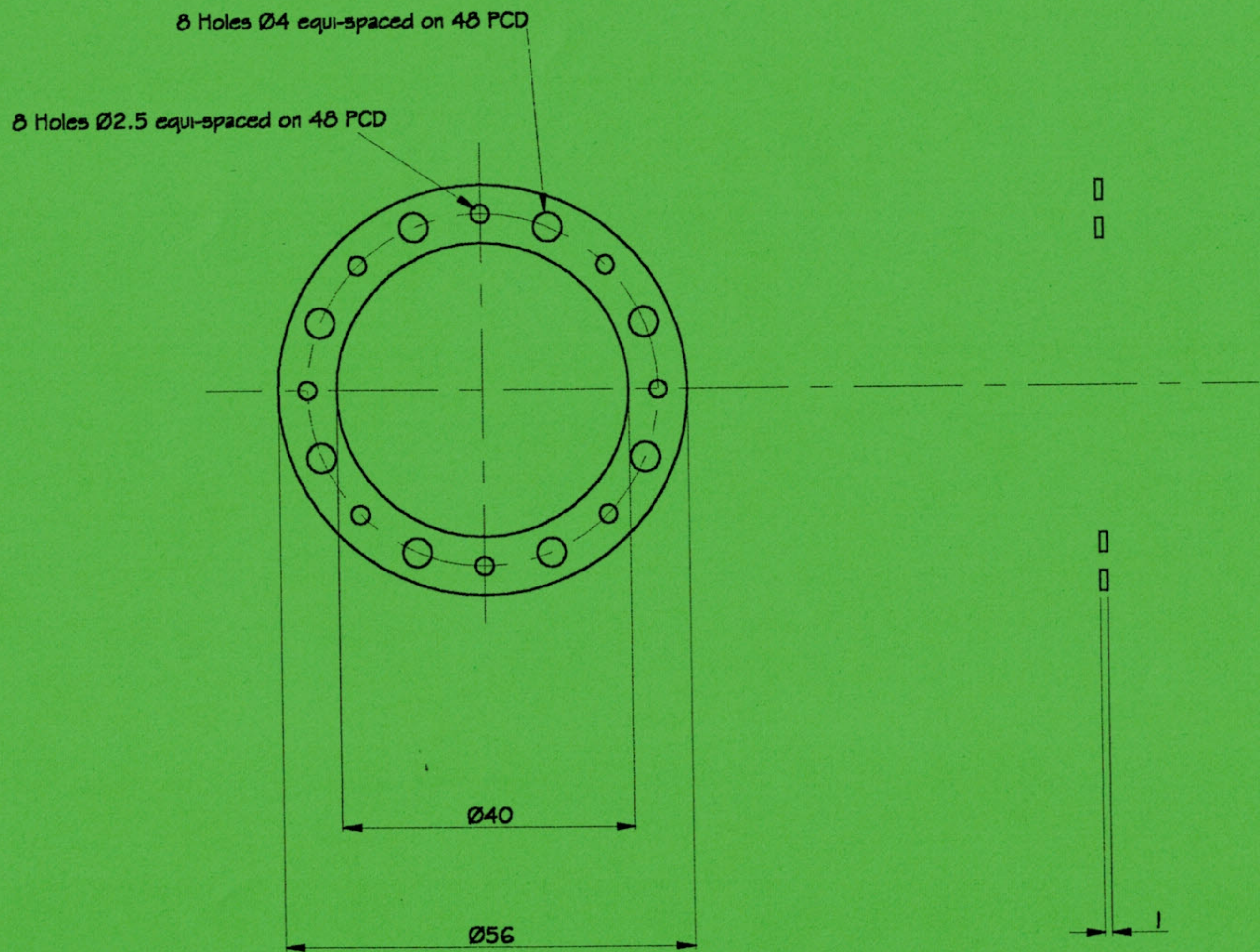
Filter Specification

Material: Stainless steel mesh
'200 mesh' with strands of .005"

Material may be obtained from:
J.A. Crewe & Co
Watery Gate Farm,
Chipping Campden,
Gloucestershire,
GL55-6QU
Tel: 01386-841979

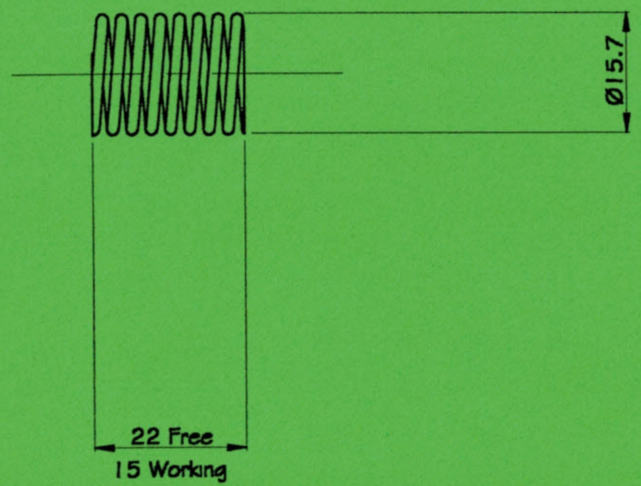
| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Filter | Issue: 2 | Part No. 008 |

Dimensions in Millimeters




| | | | | | |
|---|---|---|---|---|---|
| | | | Material: Aluminium Alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Filter Cover | Issue: 2 | Part No. 009 |

Dimensions in Millimeters

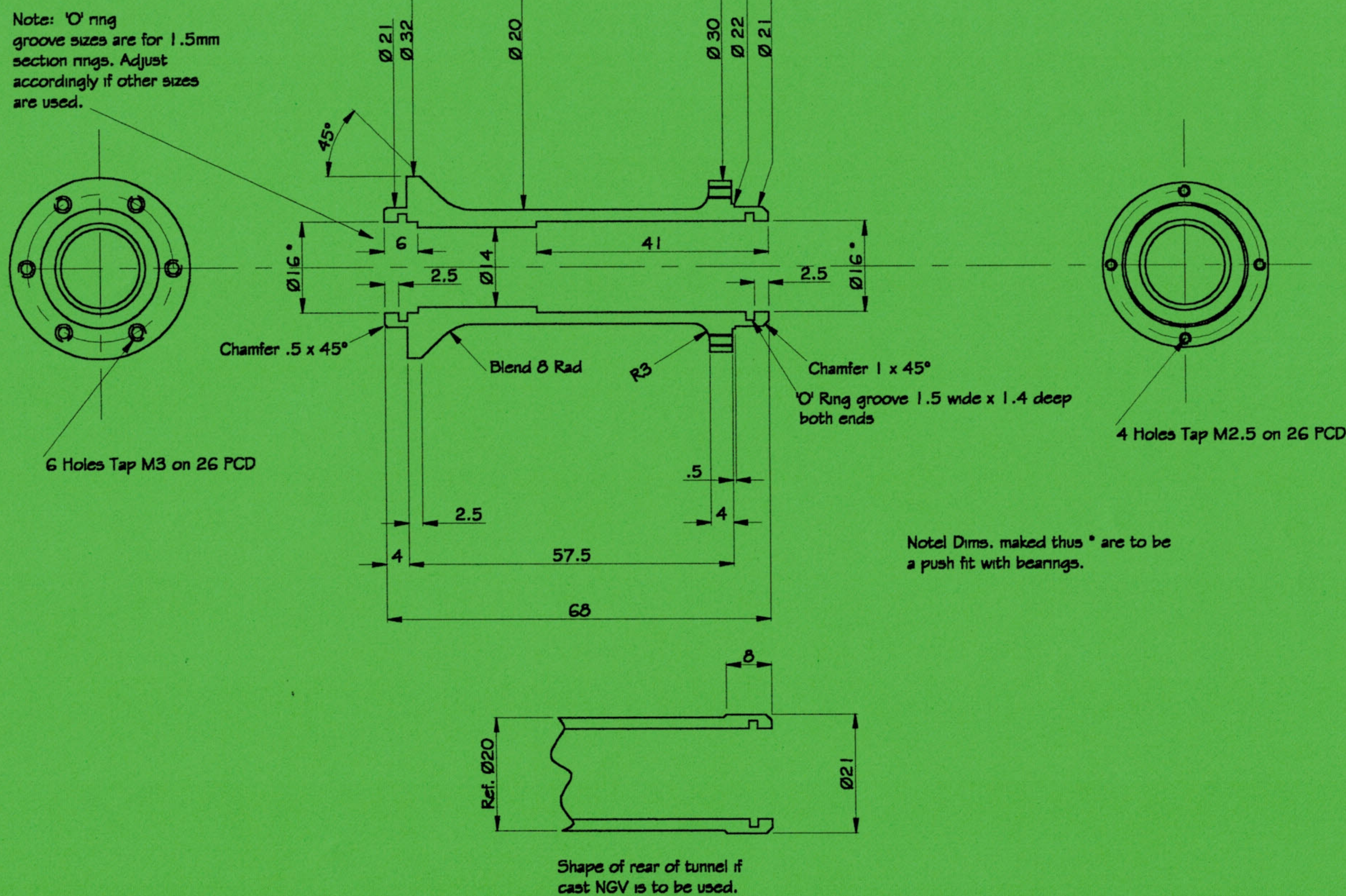



## Spring Details

Diameter; 15.7
Free Length: 22
Working Length: 15
Load at working length: 3.75kg.
Wire Dia: 1.6mm
No. working coils: 4

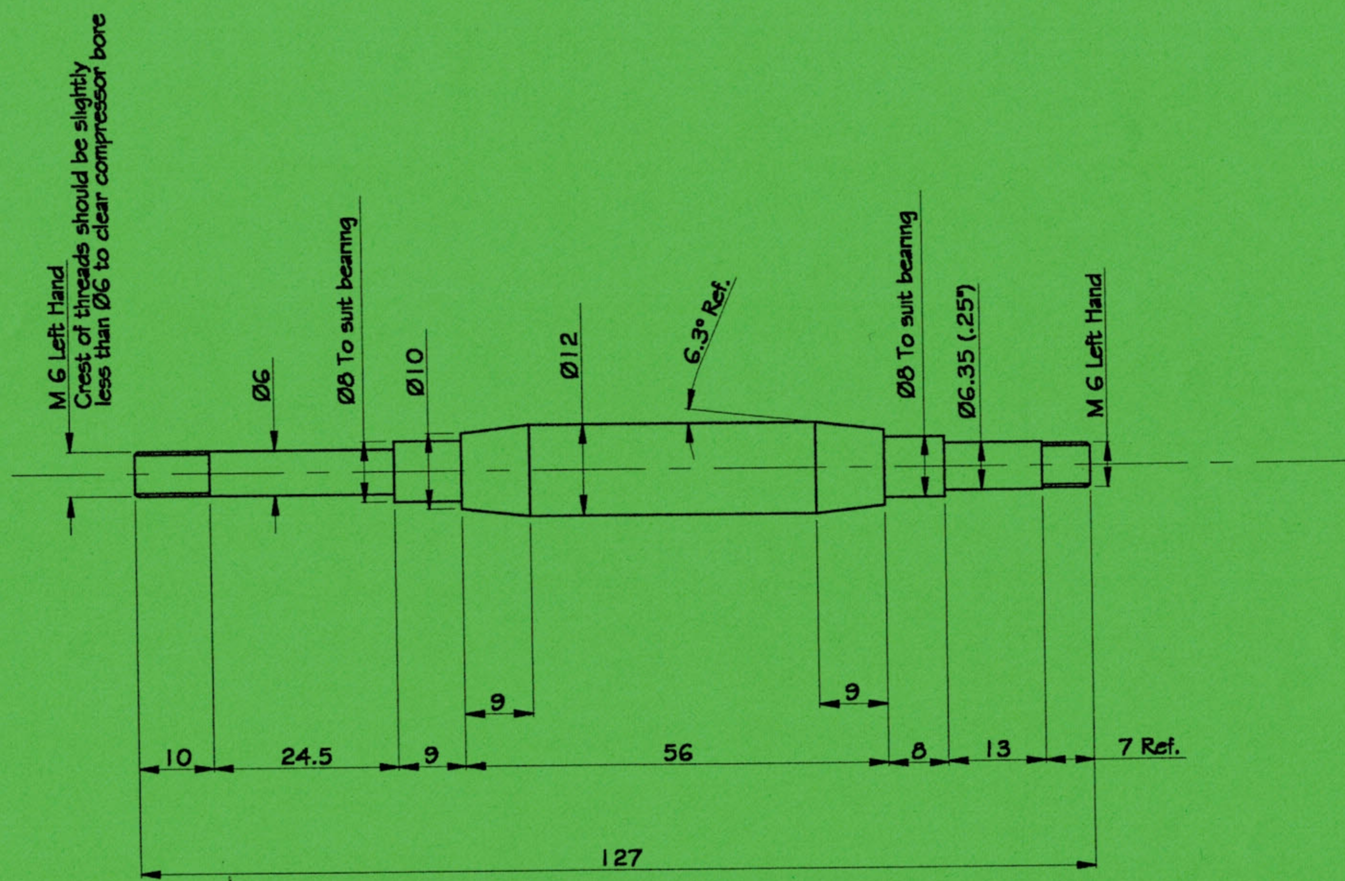
| | | | | | |
|---|---|---|---|---|---|
| | | | Material: Spring Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Spring | Issue: 2 | Part No. 010 |

Dimensions in Millimeters



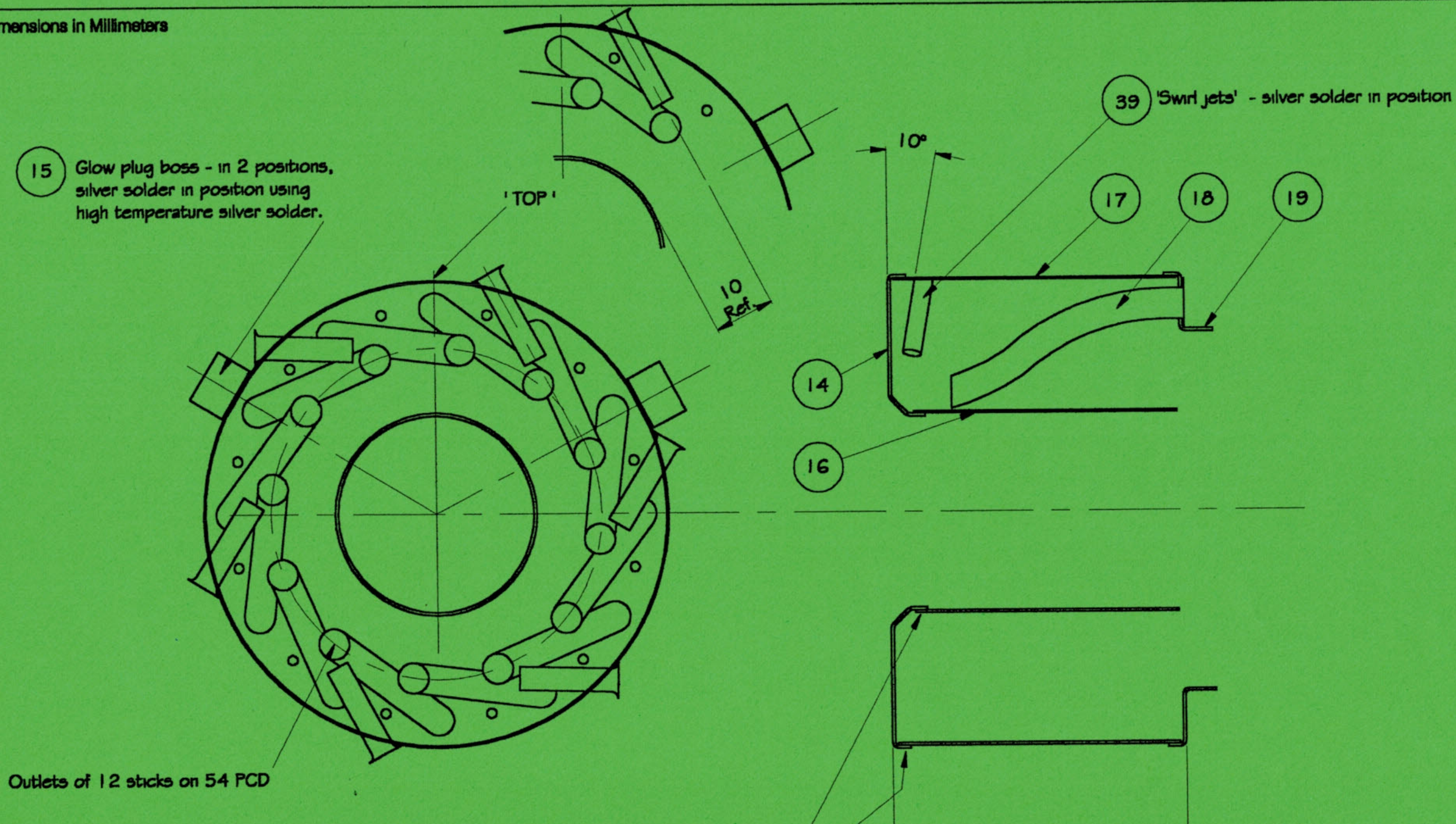

| | | | | | |
|---|---|---|---|---|---|
| | | | Material: Aluminium Alloy | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Shaft Tunnel | Issue: 3 | Part No. 011 |

Dimensions in Millimeters




| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: En 24T or Equivalent | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Shaft | Issue: 2 | Part No. 012 |

Dimensions in Millimeters

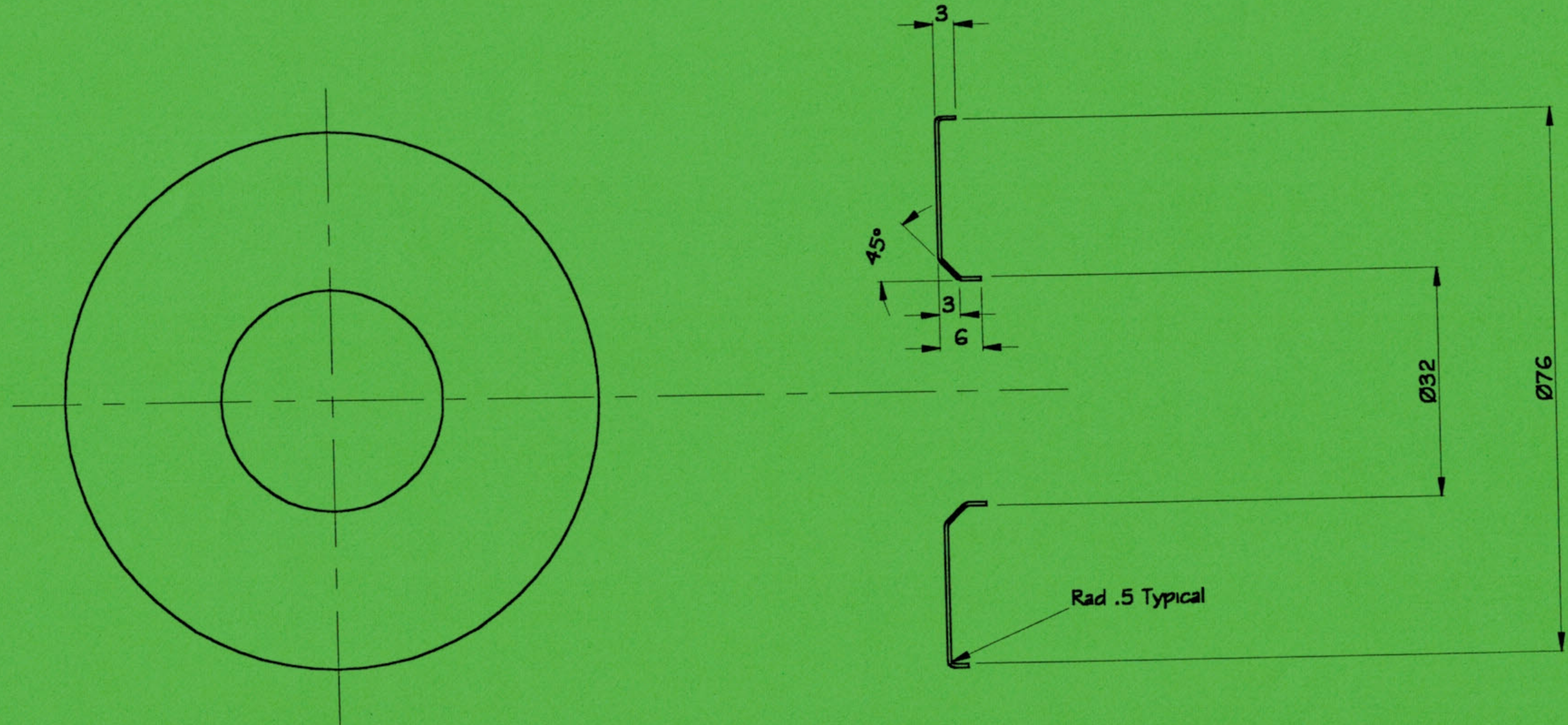



Ref. View from front

(End caps omitted for clarity)

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: As details | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Combustion Chamber Sub - Assy | Issue: 4 | Part No. 013 |

Dimensions in Millimeters

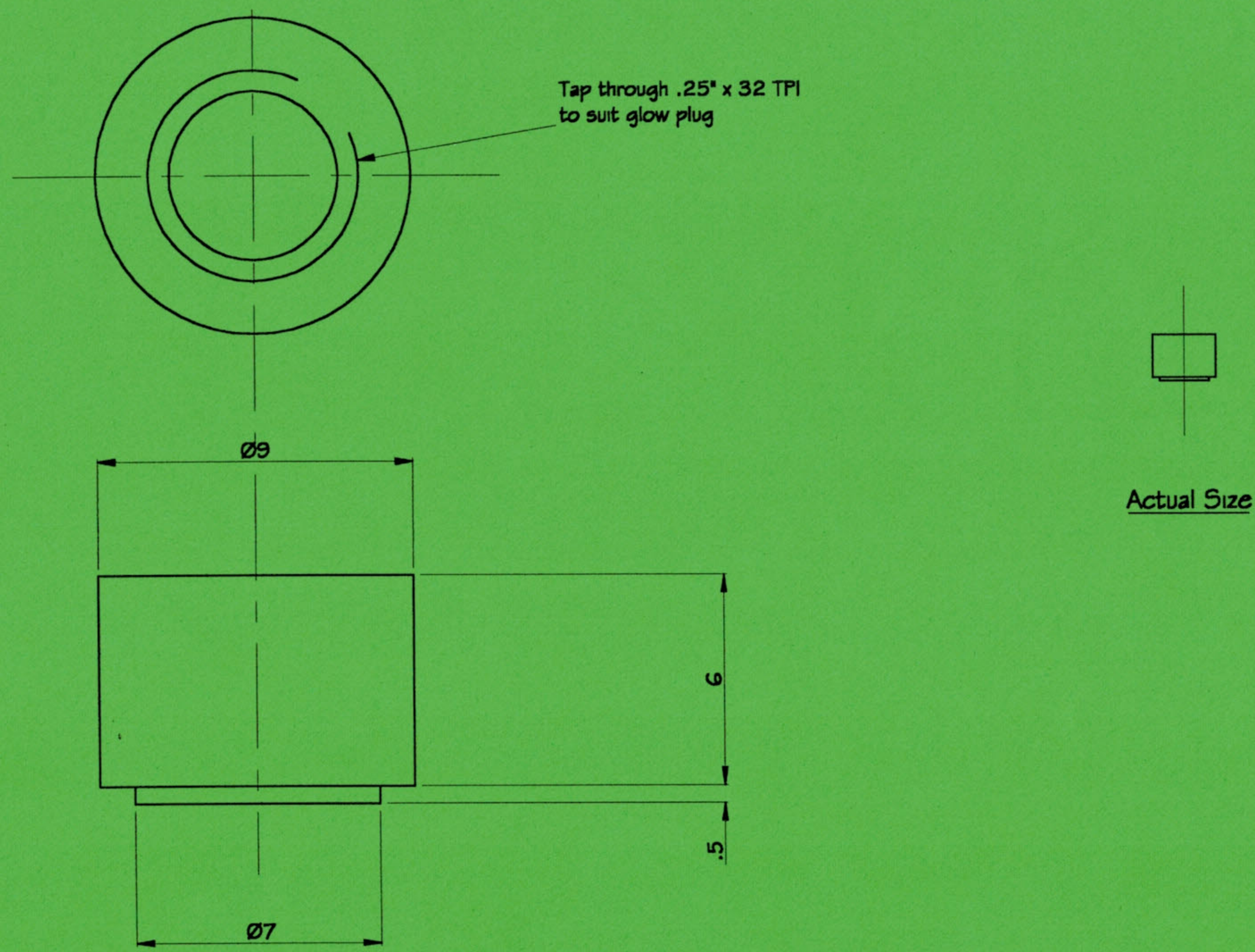



Material: Stainless Steel sheet - .4mm Thick

Title: Combustion Chamber Front | Issue: 1 | Part No. 014

Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54

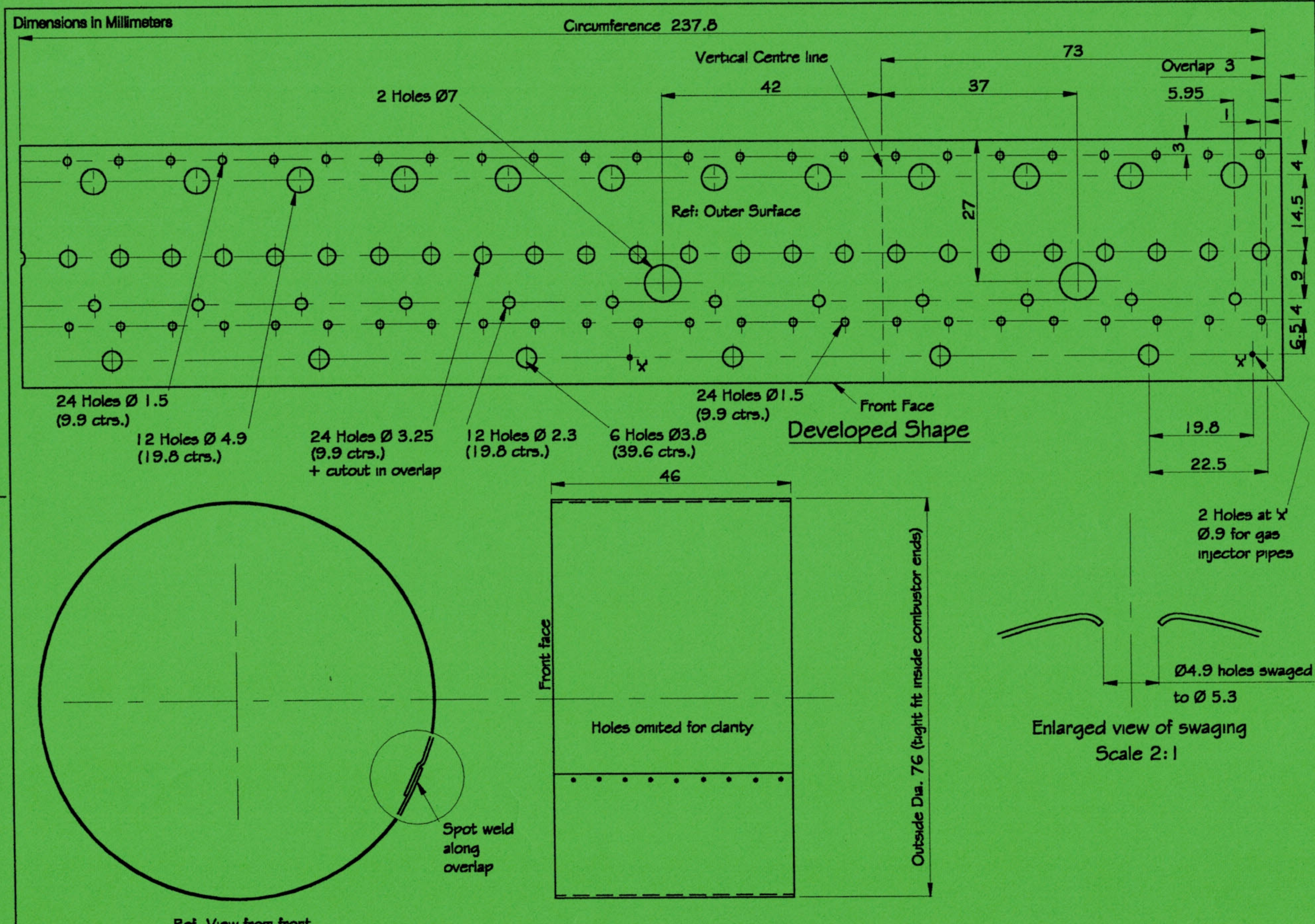
Dimensions in Millimeters



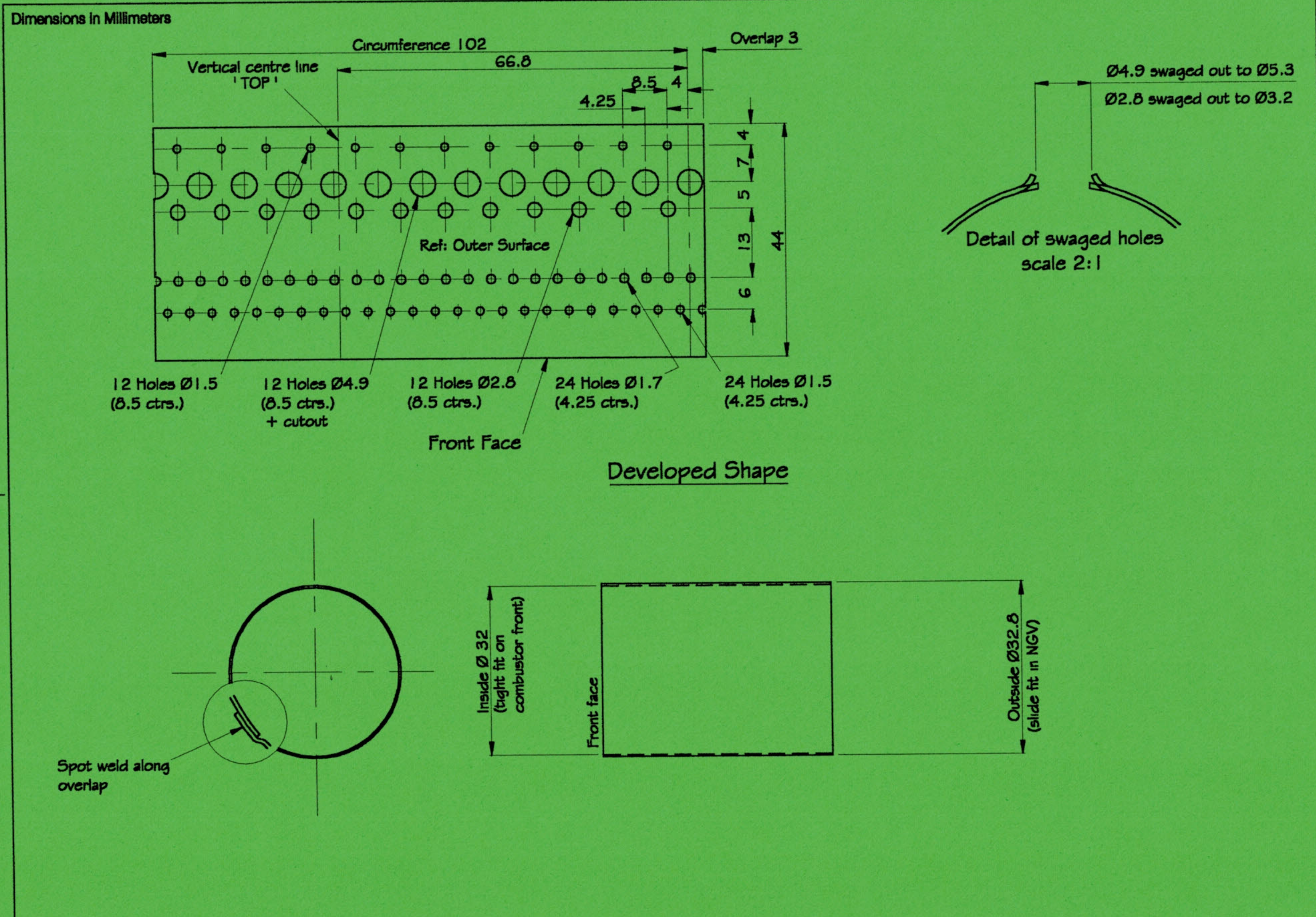

Actual Size

Enlarged View Scale 5:1

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Glow Plug Boss | Issue: 1 | Part No. 015 |

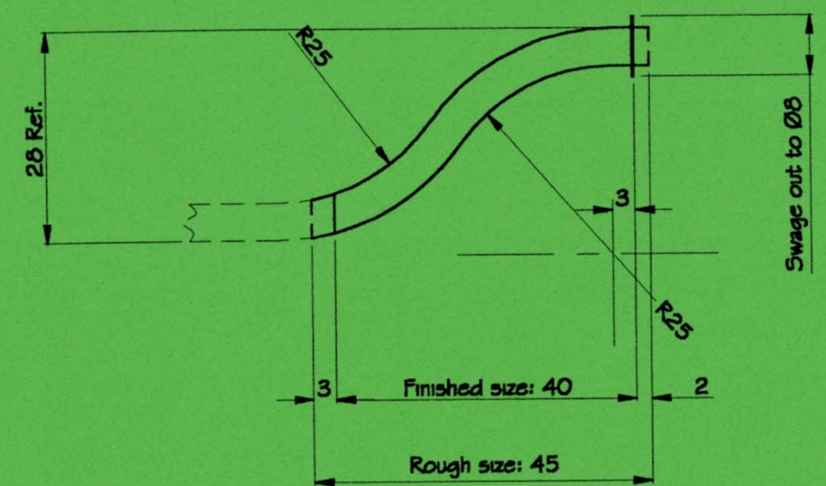



| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel sheet - .4mm thick | | |
| Drawn: Terry Lee | Third Angle Projection | © Mike Murphy | Turbine - MW54 | Title: Combustor - Outer Wrapper | Issue: 4 | Part No. 017 |

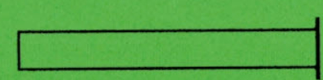



| | | | | | |
|---|---|---|---|---|---|
| | | | | Material: Stainless Steel sheet .4mm thick | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Combustor - Inner Wrapper | Issue: 2 | Part No. 016 |

Dimensions in Millimeters

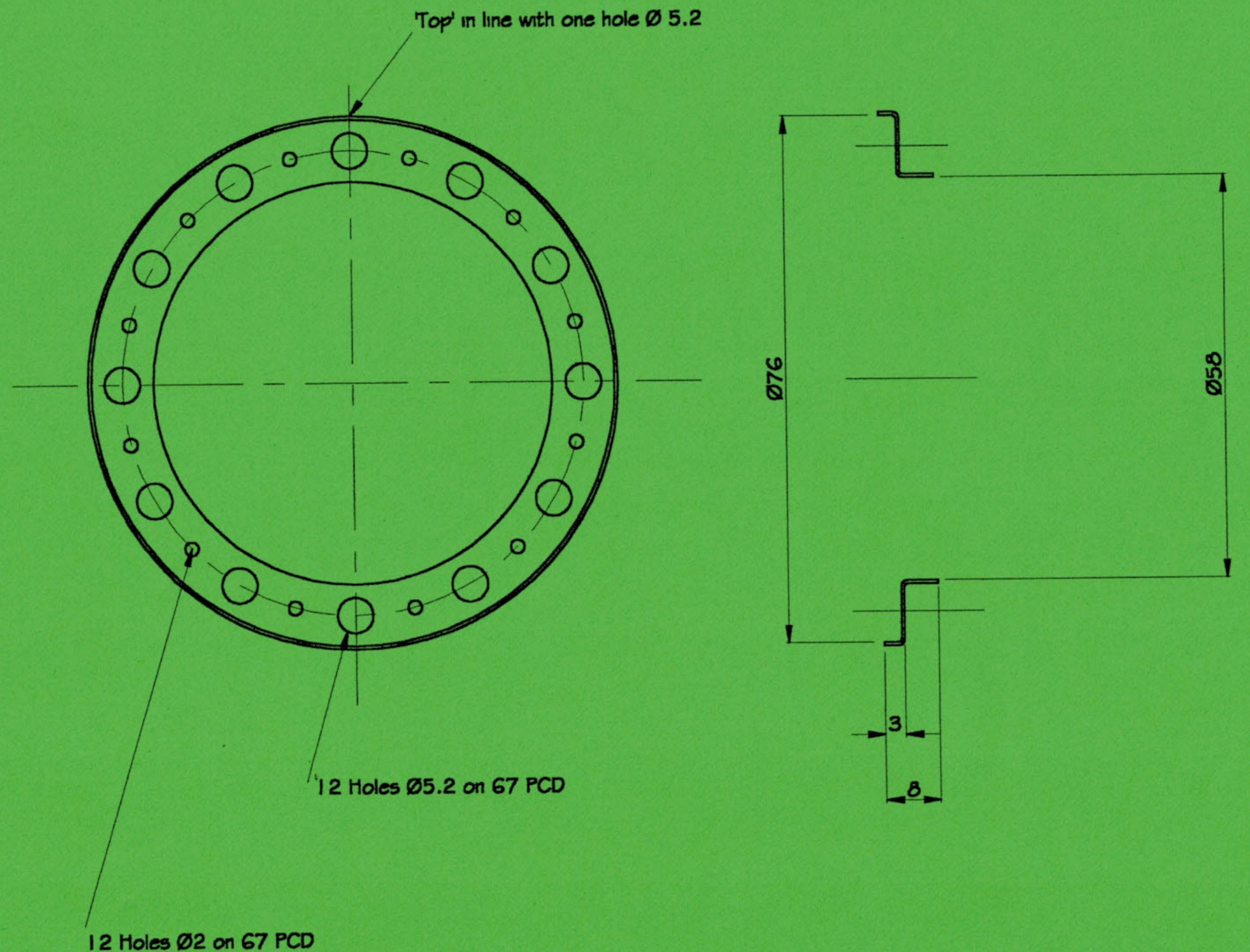



Make from Stainless Steel tube
Ø5 x .3 wall thickness



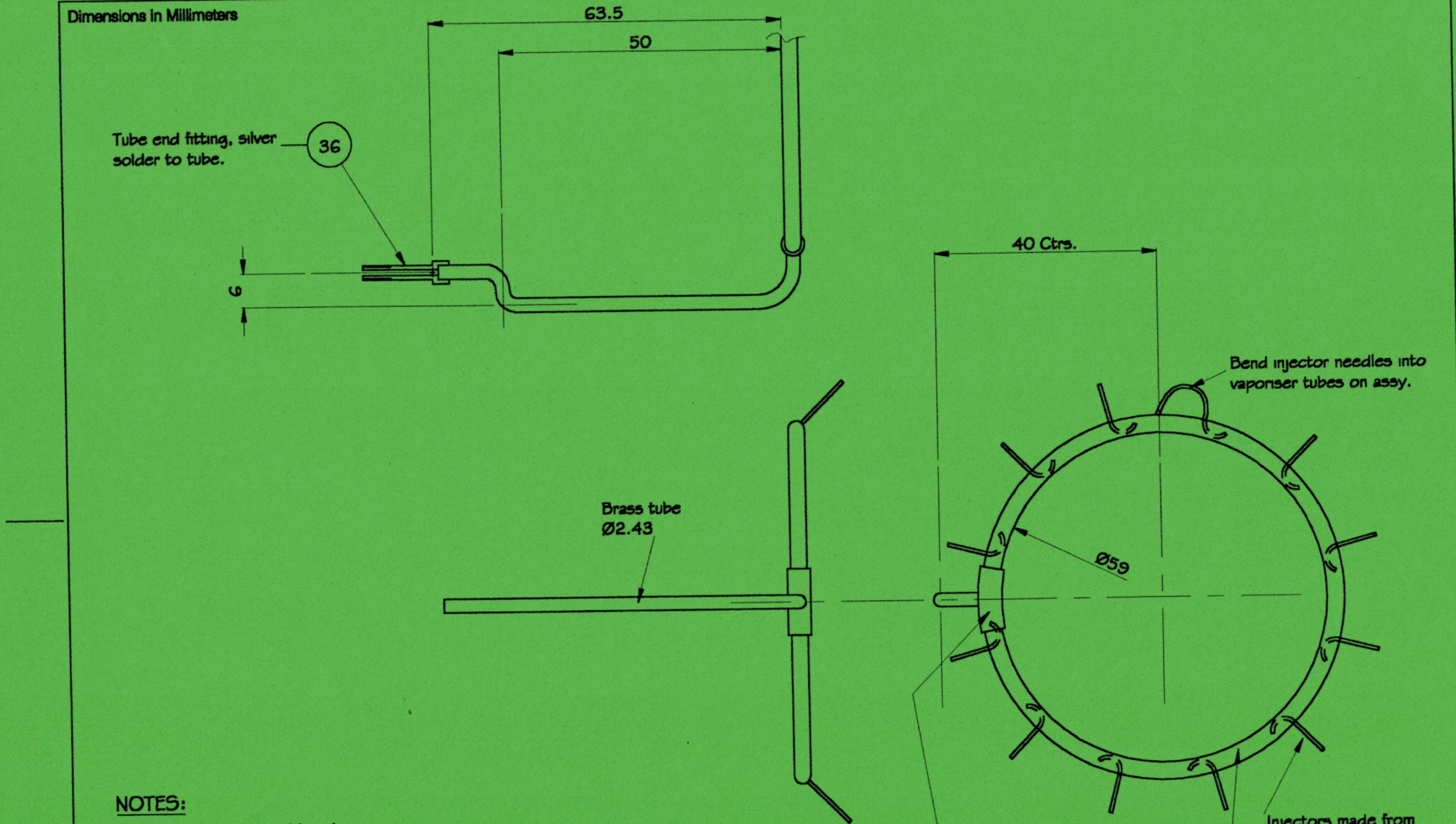
| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: See Above | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Vaporiser Tube | Issue: 3 | Part No. 018 |

Dimensions in Millimeters




Material: Stainless Steel sheet - .4mm thick

| | | | | | | |
|---|---|---|---|---|---|---|
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Combustor Rear | Issue: 2 | Part No. 019 |



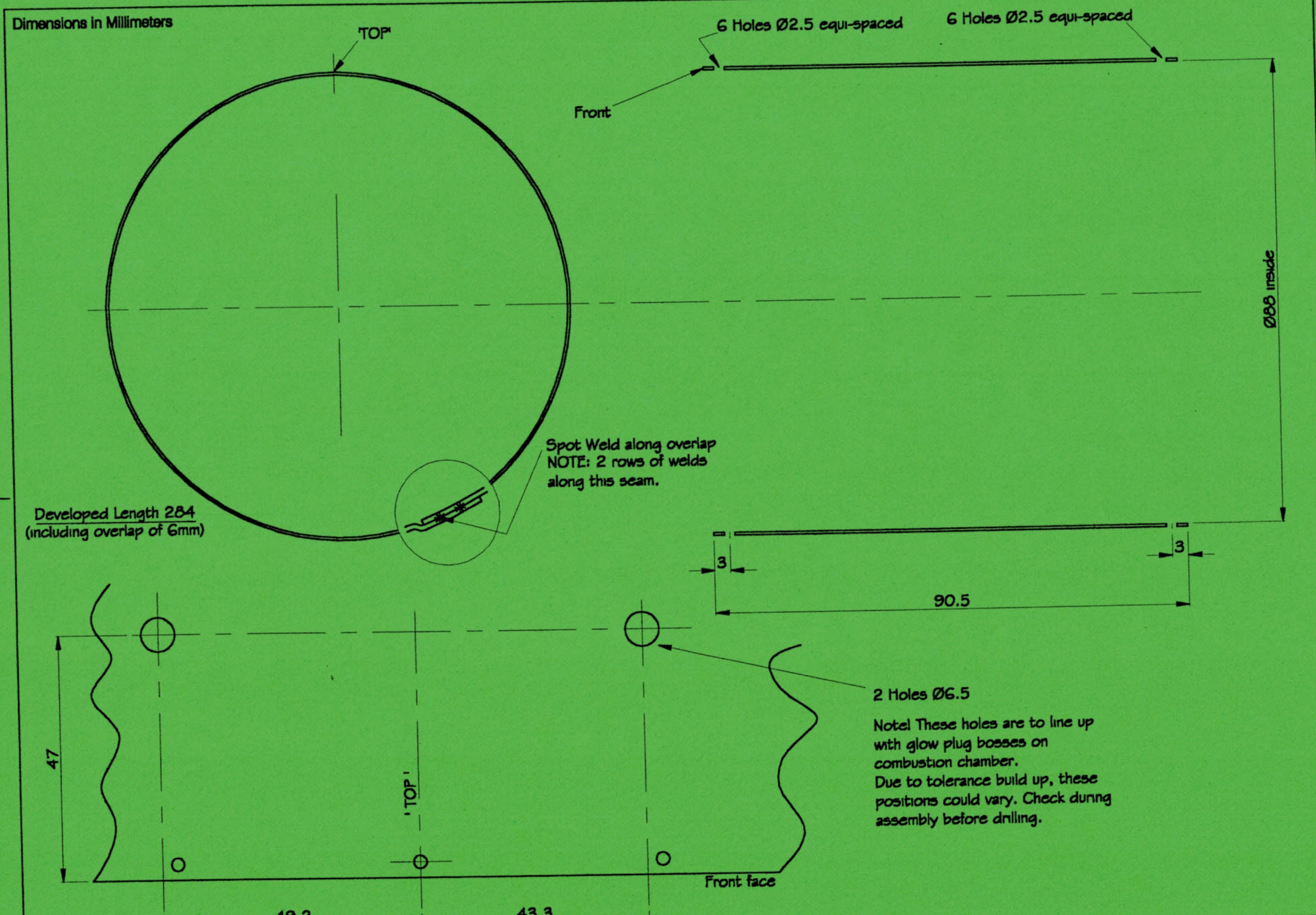

## NOTES:

All joints to be silver soldered
It is important to ensure that no flux or solder is trapped inside the assembly.

Tube diameters quoted are Outside dia.

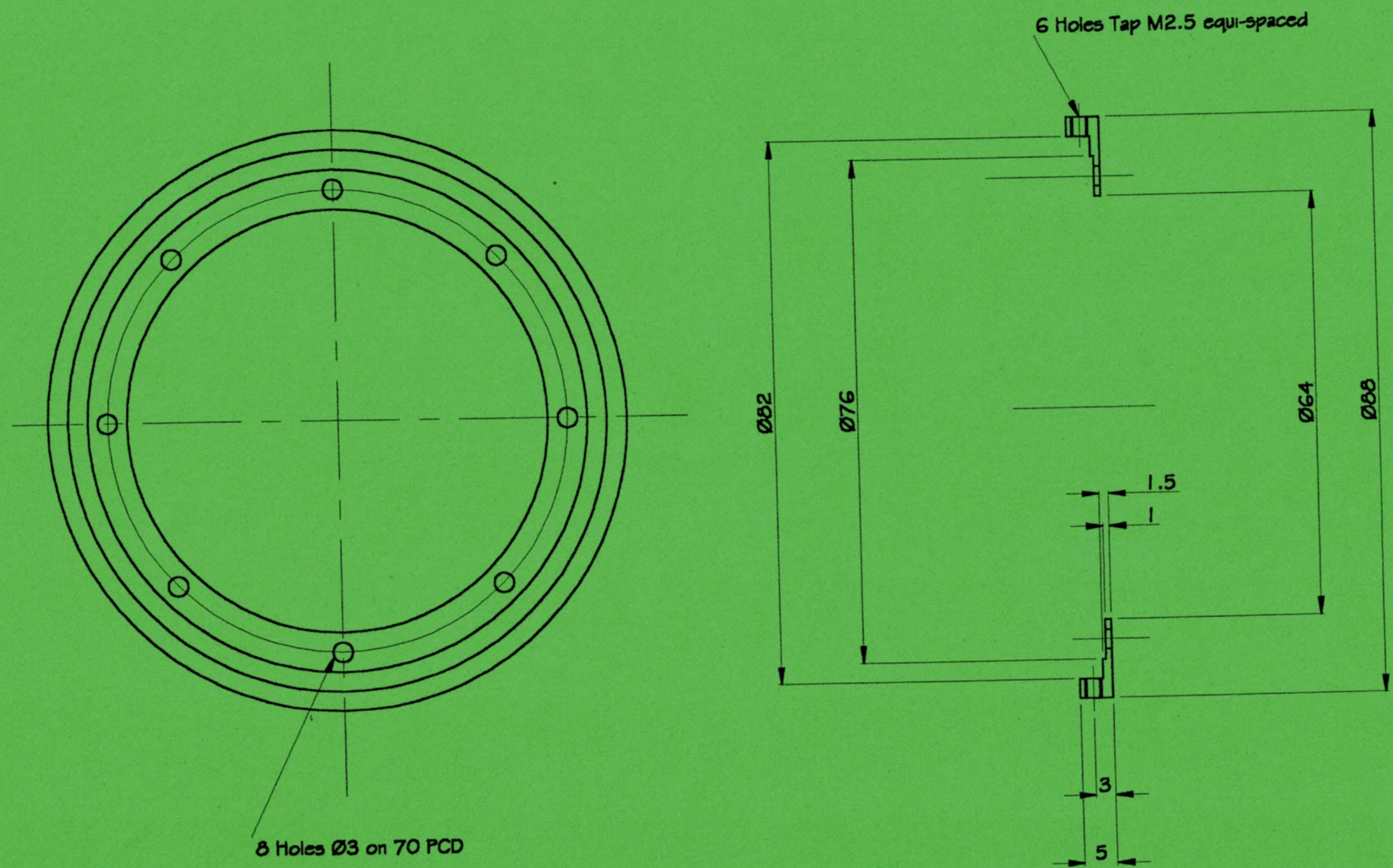
The assembly will require clipping (not shown) to the combustion chamber, position to suit.
Ensure no holes are covered by clips or tube.

| | | | | | |
|---|---|---|---|---|---|
| | | | Material: See above | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Fuel Pipe Assy. | Issue: 3 | Part No. 020 |



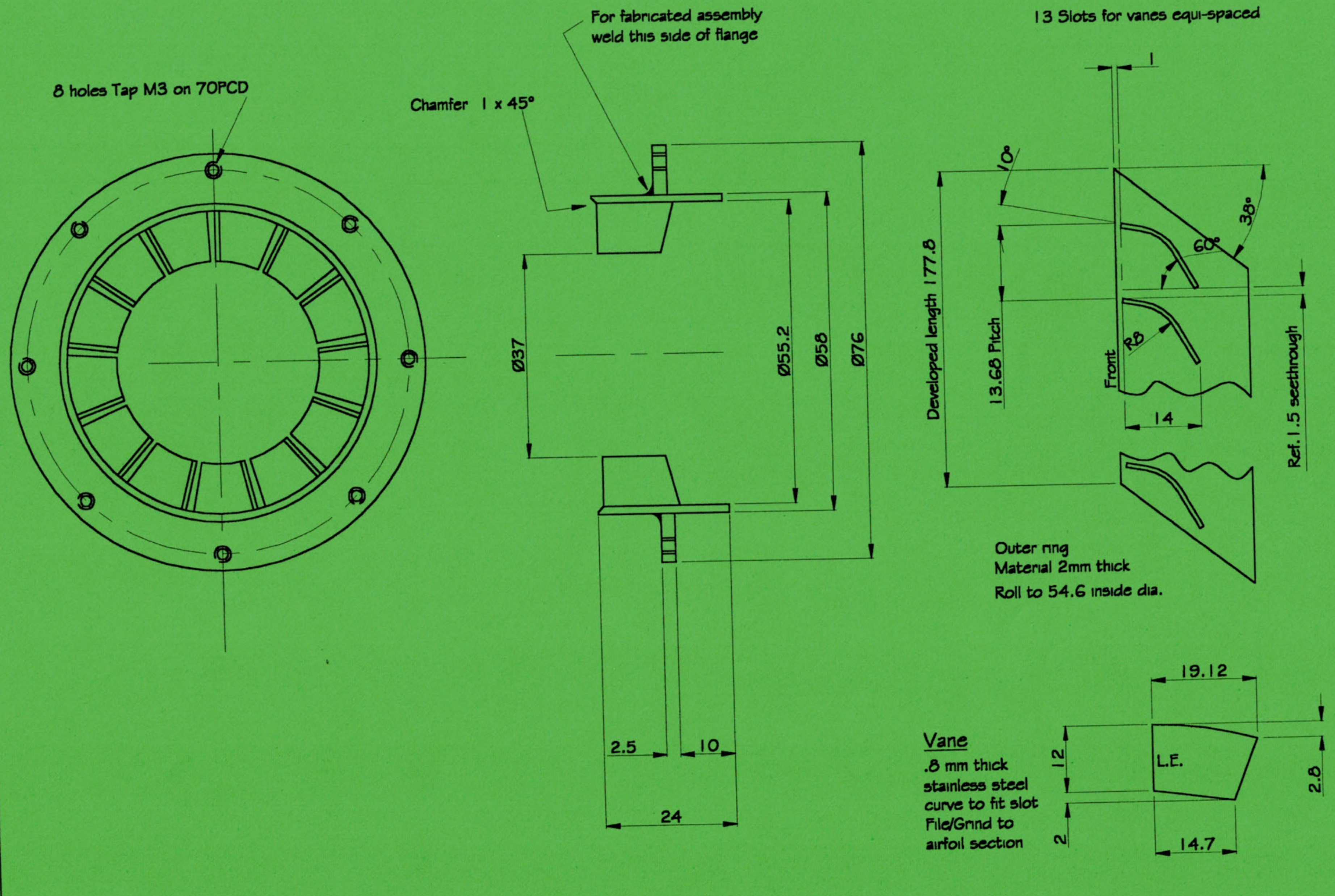

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel - .4 thick | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Case Outer | Issue: 3 | Part No. 021 |

Dimensions in Millimeters




| | | | | | |
|---|---|---|---|---|---|
| Material: Mild Steel | | | | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Case Rear | Issue: 3 | Part No. 022 |

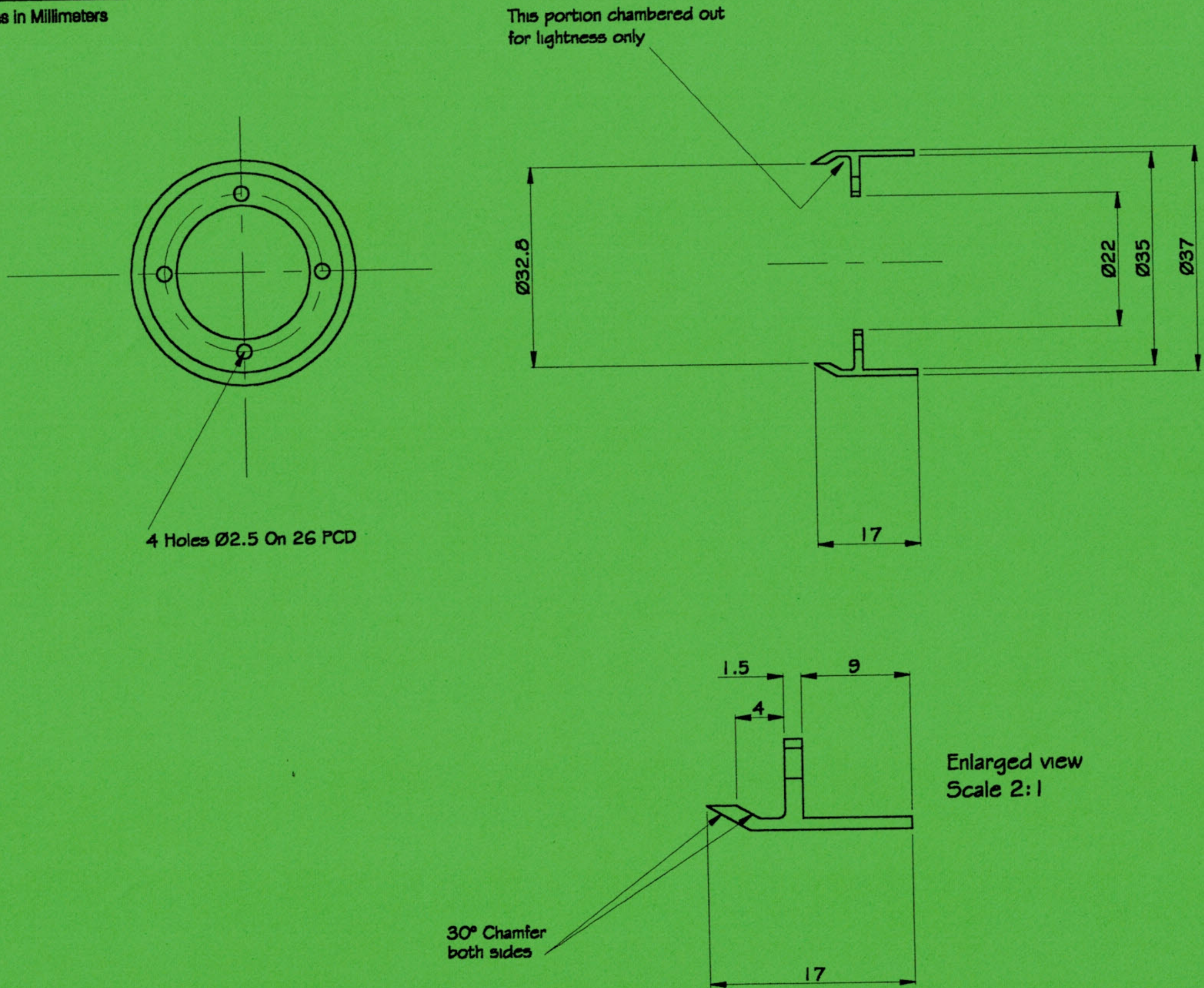
Dimensions in Millimeters




| Material: Stainless Steel | | |
|---|---|---|
| Title: NGV Outer | Issue: 1 | Part No. 023 |

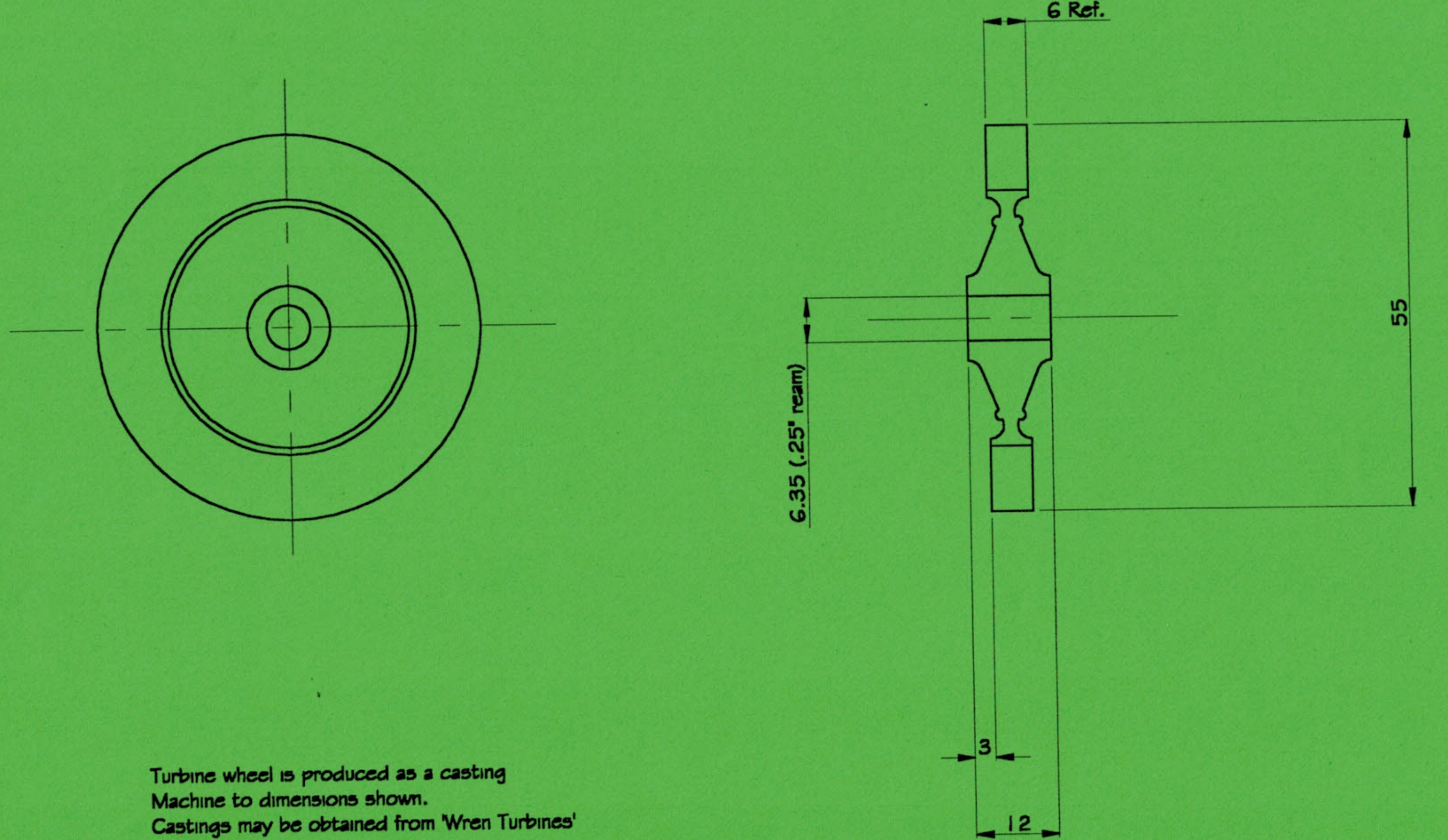
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 |
|---|---|---|---|

Dimensions in Millimeters




| | | | | | |
|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: NGV Inner | Issue: 2 | Part No. 024 |

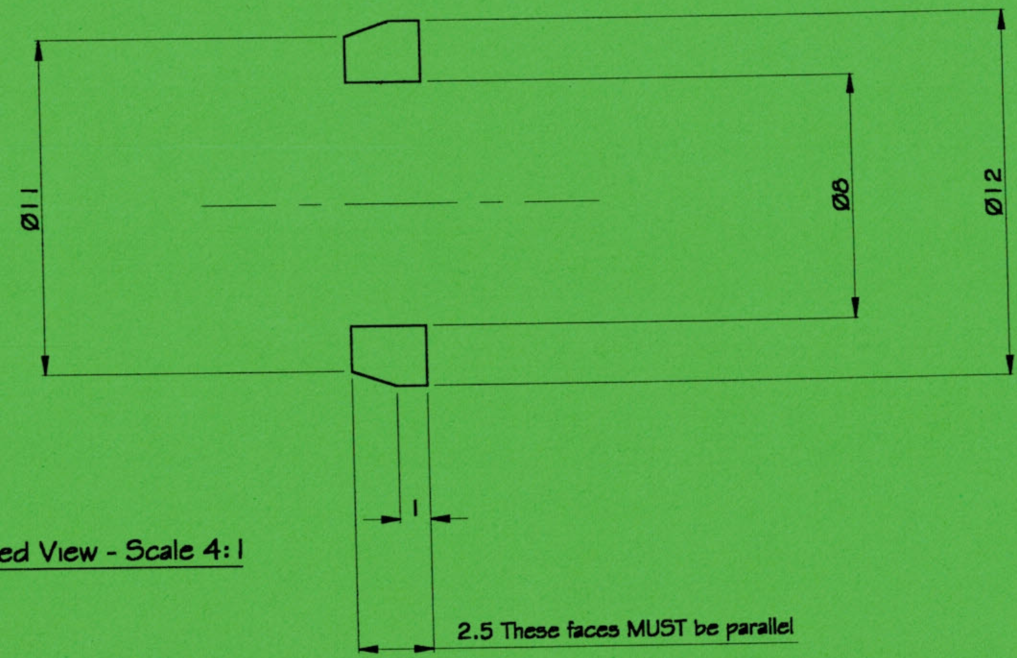
Dimensions in Millimeters



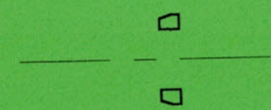

Turbine wheel is produced as a casting
Machine to dimensions shown.
Castings may be obtained from 'Wren Turbines'

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Inconel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Turbine wheel | Issue: 1 | Part No. 025 |

Dimensions in Millimeters



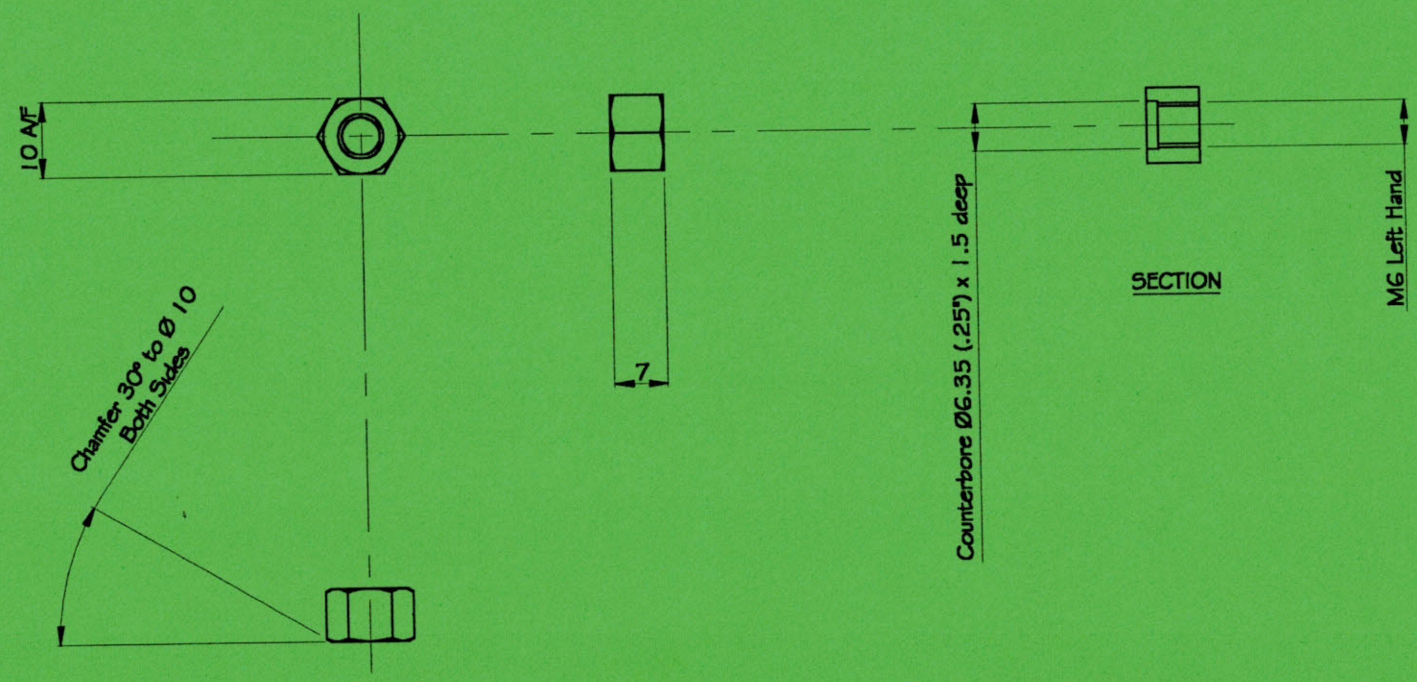

Enlarged View - Scale 4:1



Actual Size

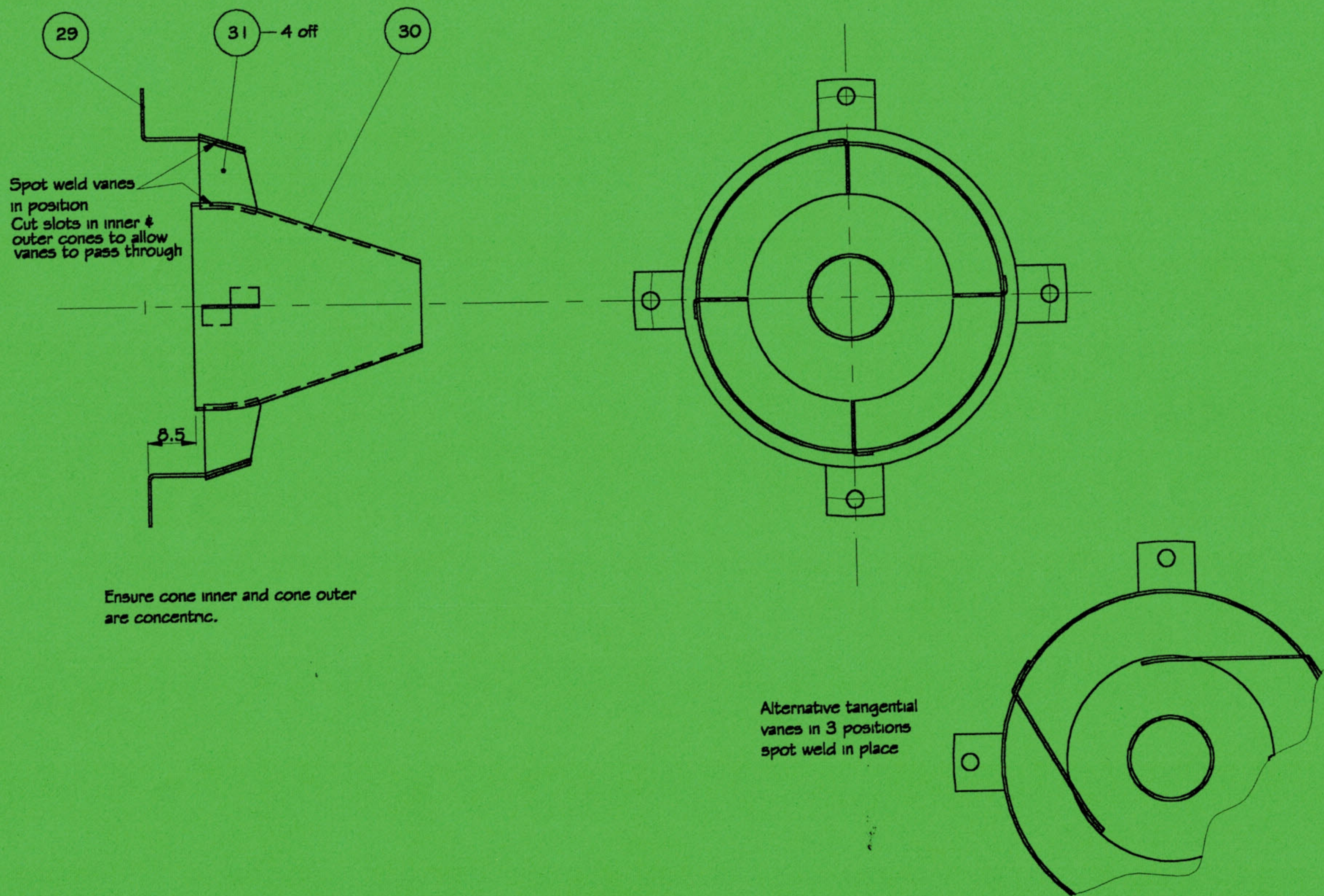
| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Rear Spacer | Issue: 2 | Part No. 026 |

Dimensions in Millimeters




| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Turbine Nut | Issue: 1 | Part No. 027 |

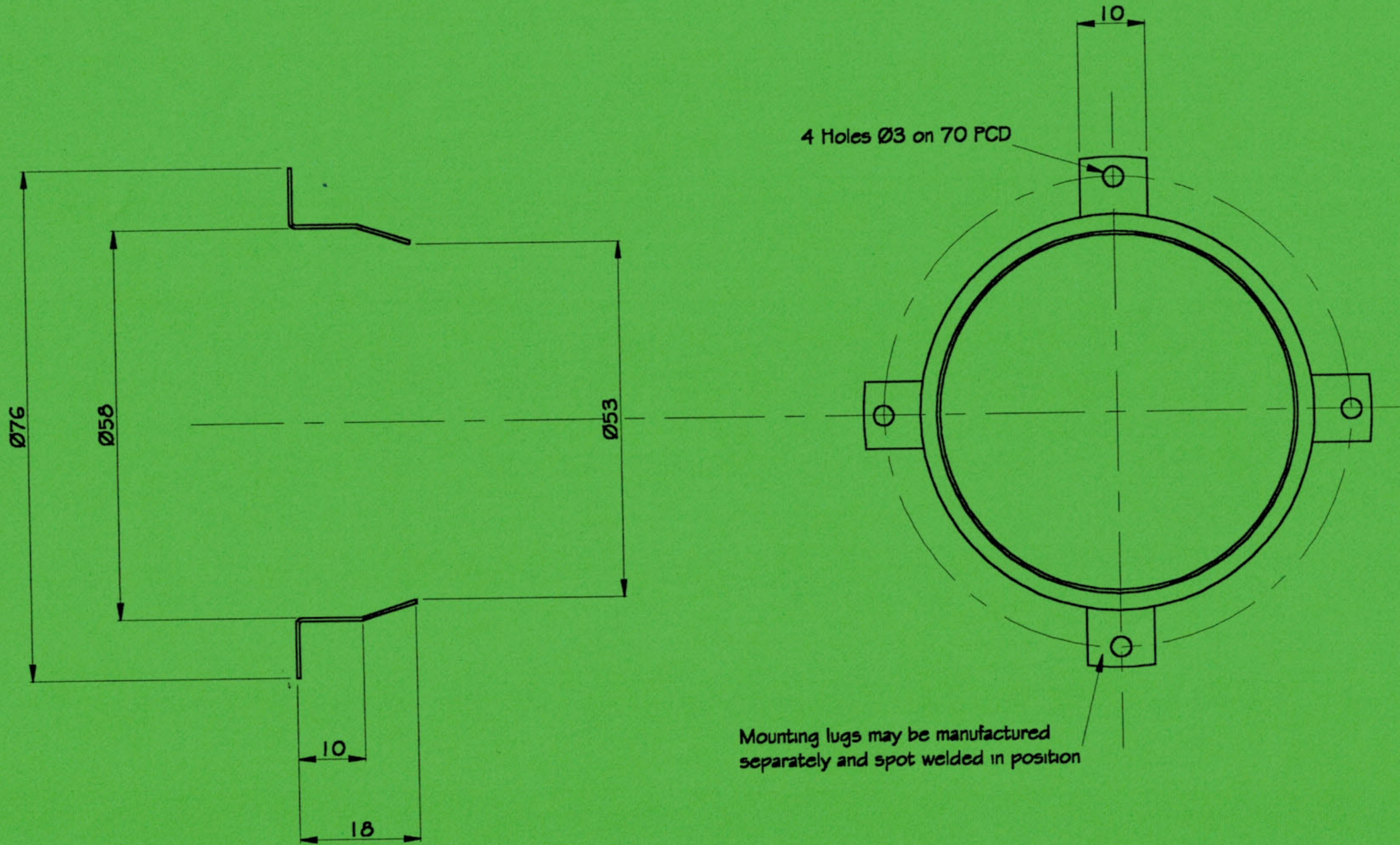
Dimensions in Millimeters




Material: As Details

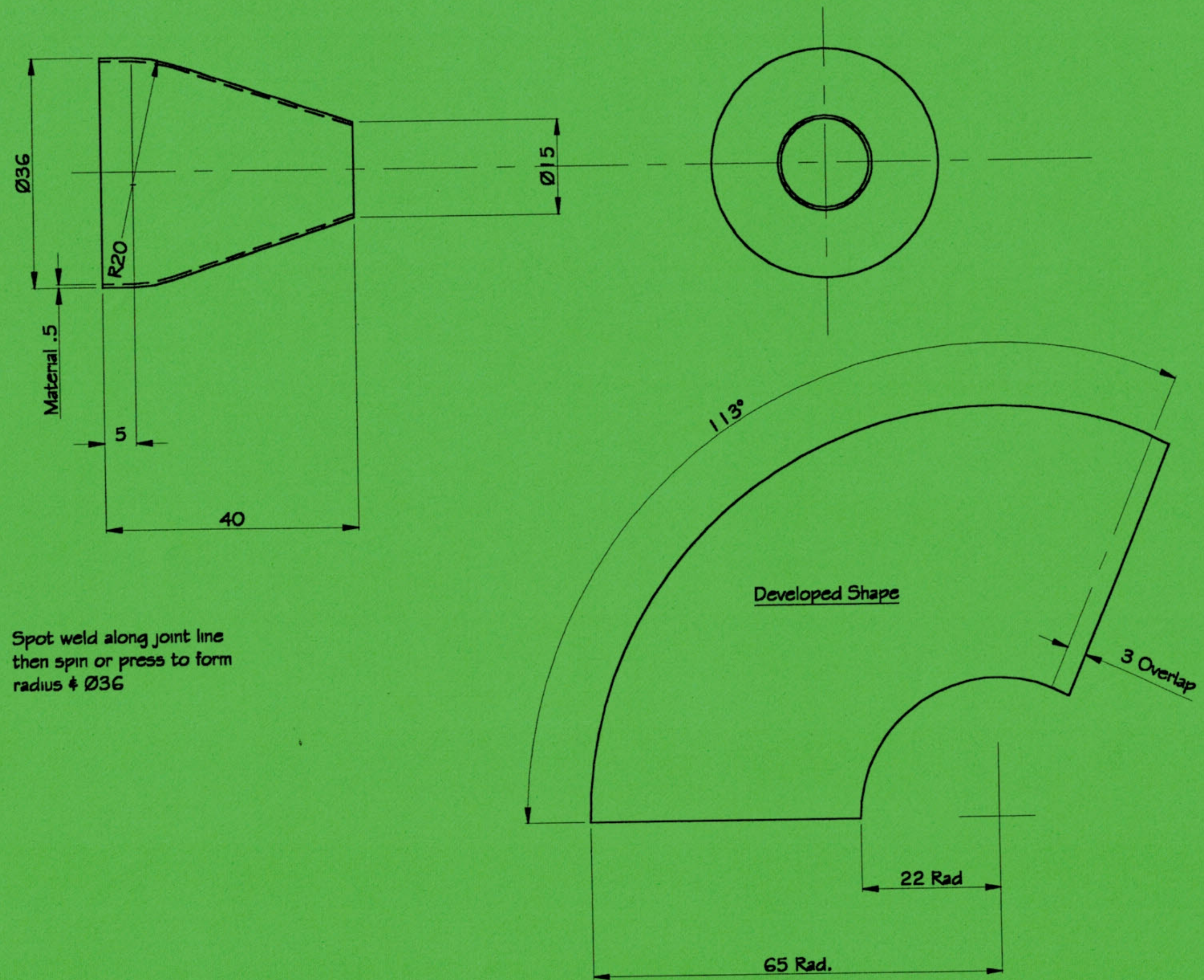
Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Exhaust Cone Sub Assy. | Issue: 2 | Part No. 028

Dimensions in Millimeters




| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel Sheet | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Cone Outer | Issue: 1 | Part No. 029 |

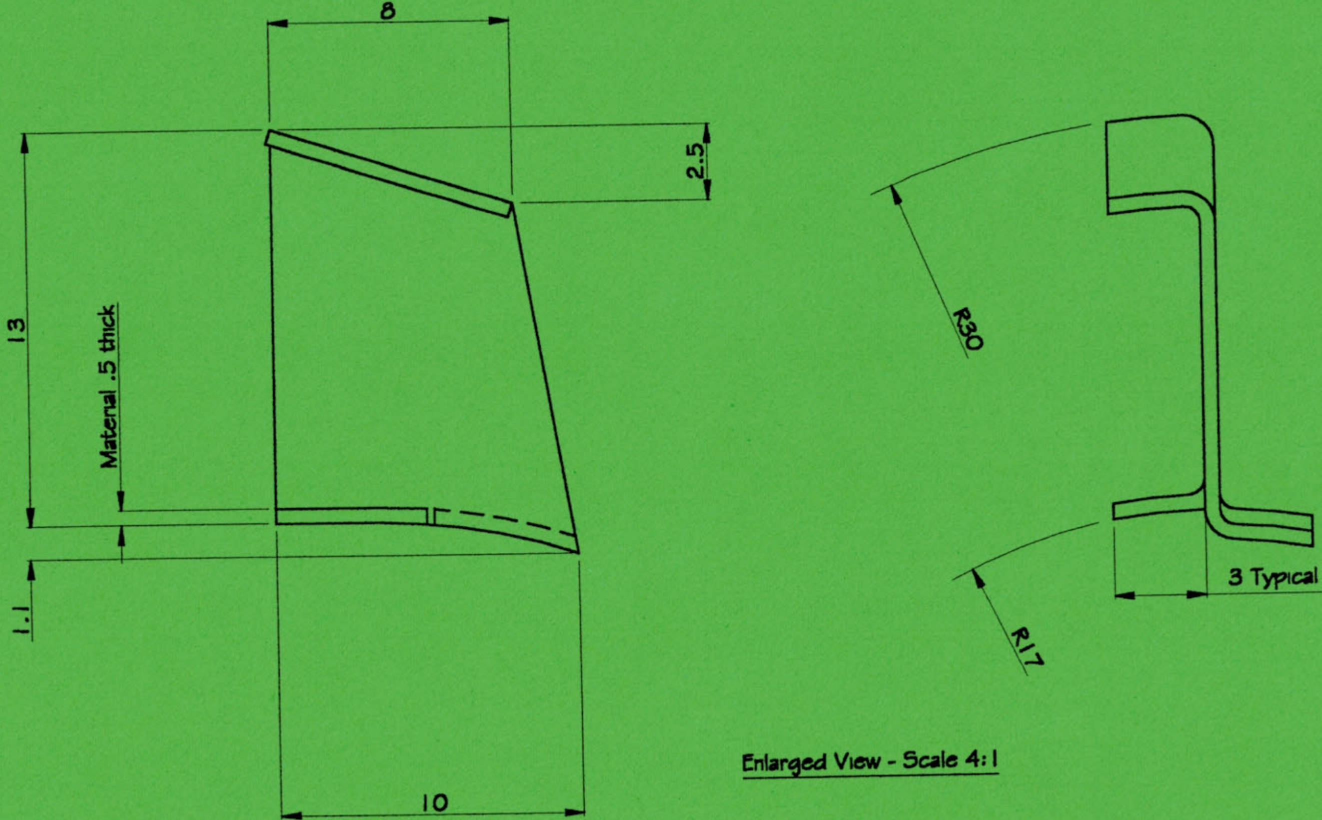
Dimensions in Millimeters




Spot weld along joint line
then spin or press to form
radius & Ø36

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel Sheet | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Cone Inner | Issue: 1 | Part No. 030 |

Dimensions in Millimeters

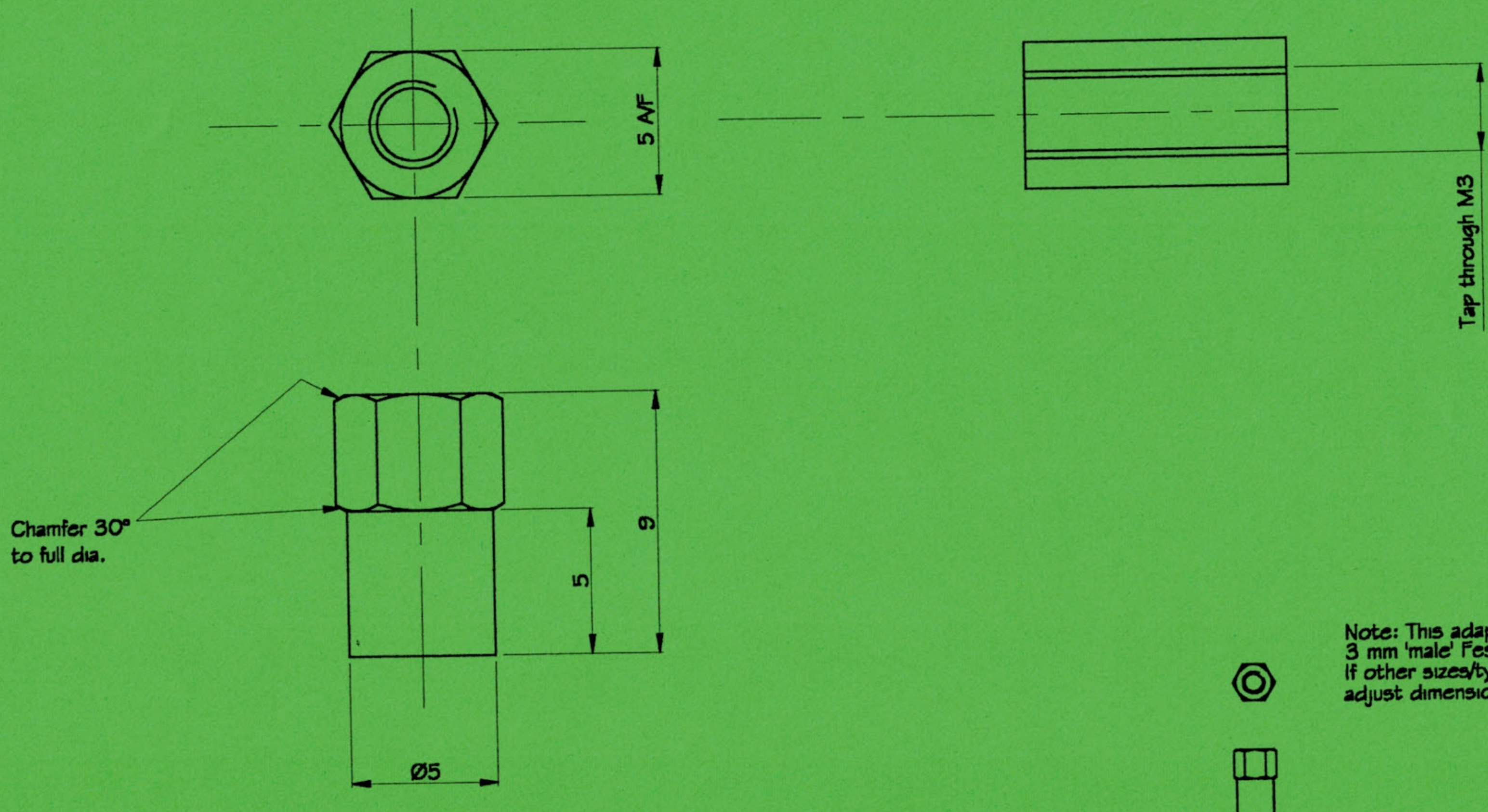



Enlarged View - Scale 4:1

Actual Size

| | | | | | |
|---|---|---|---|---|---|
| | | | | Material: Stainless Steel Sheet | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Outlet Vane | Issue: 2 |
| | | | | | Part No. 031 |

Dimensions in Millimeters



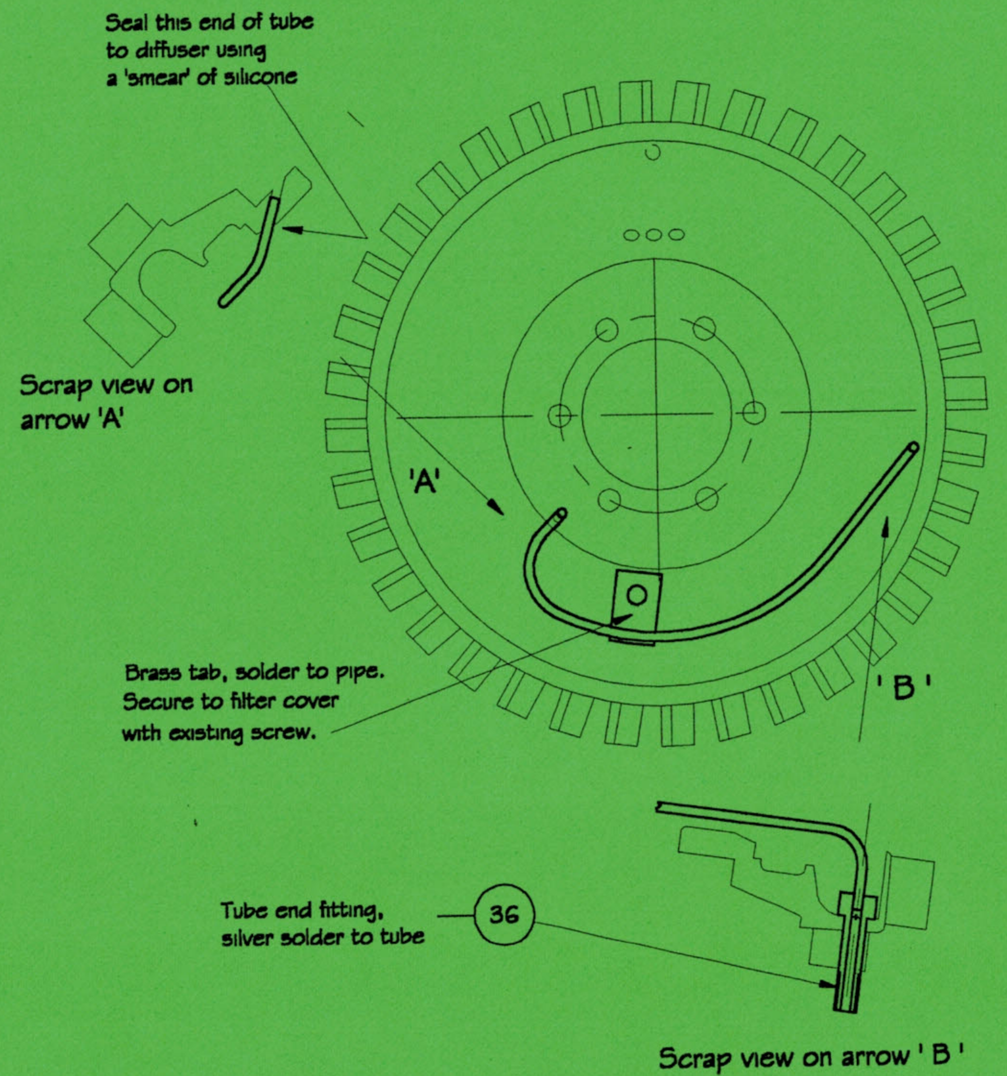

Enlarged view - Scale 4:1

Note: This adaptor is for use with
3 mm 'male' Festo type fittings.
If other sizes/types are to be used,
adjust dimensions accordingly.

Actual Size

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Brass | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Adaptor | Issue: 2 | Part No. 032 |

Dimensions In Millimeters



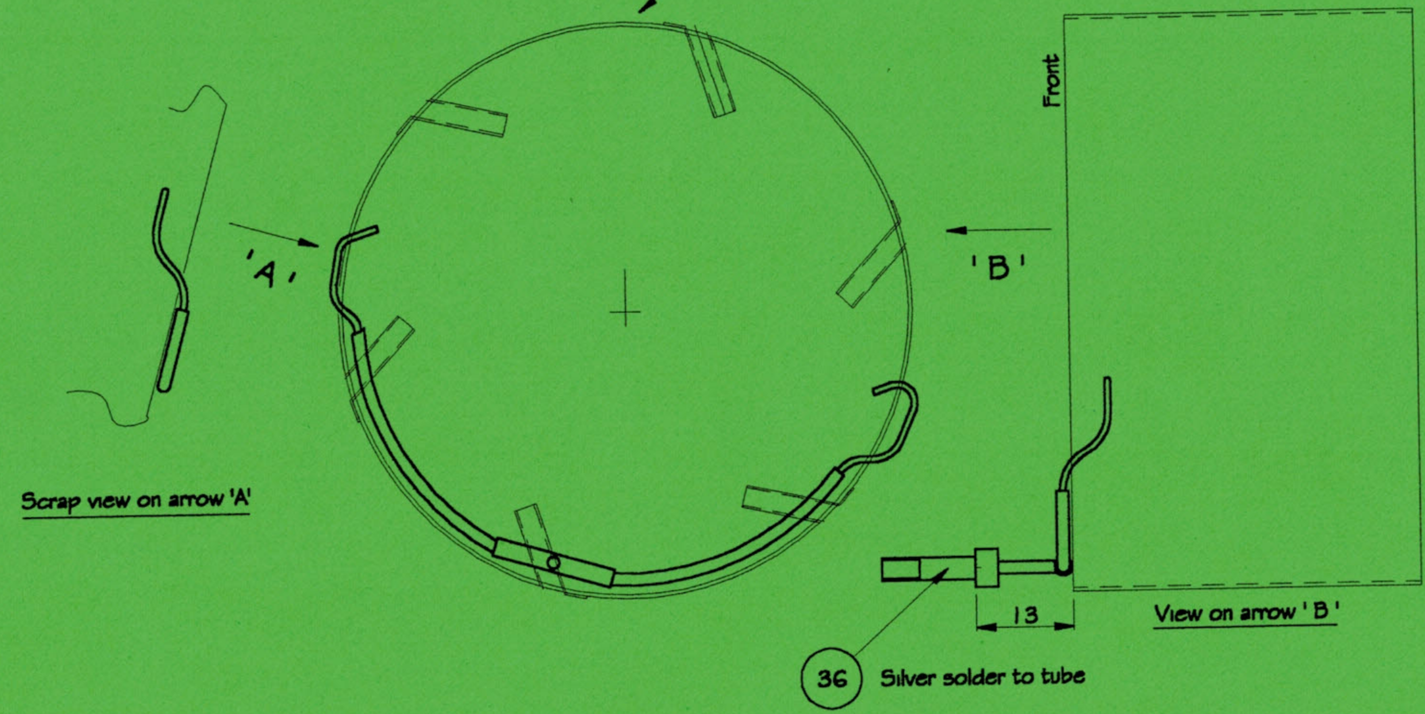

View on rear of diffuser

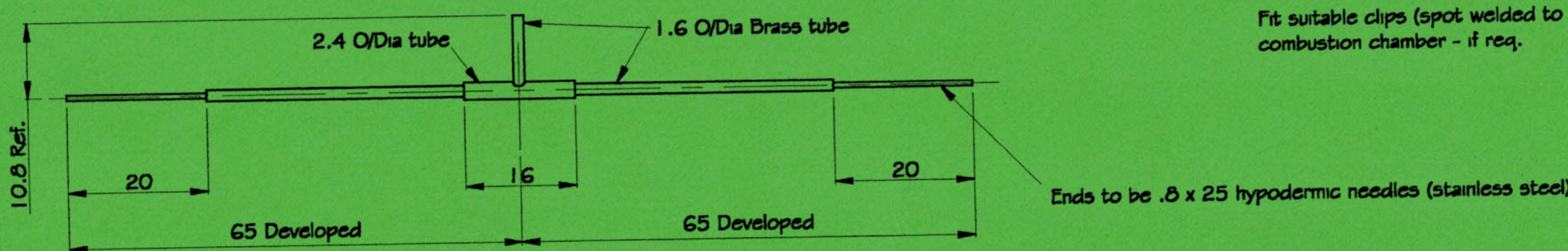
NOTE: Filter and filter cover must be fitted before tube is fitted to diffuser.

Material - Brass tube 1.6 mm O /Dia.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Brass Tube | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Lubrication pipe | Issue: 2 | Part No. 033 |

Dimensions in Millimeters



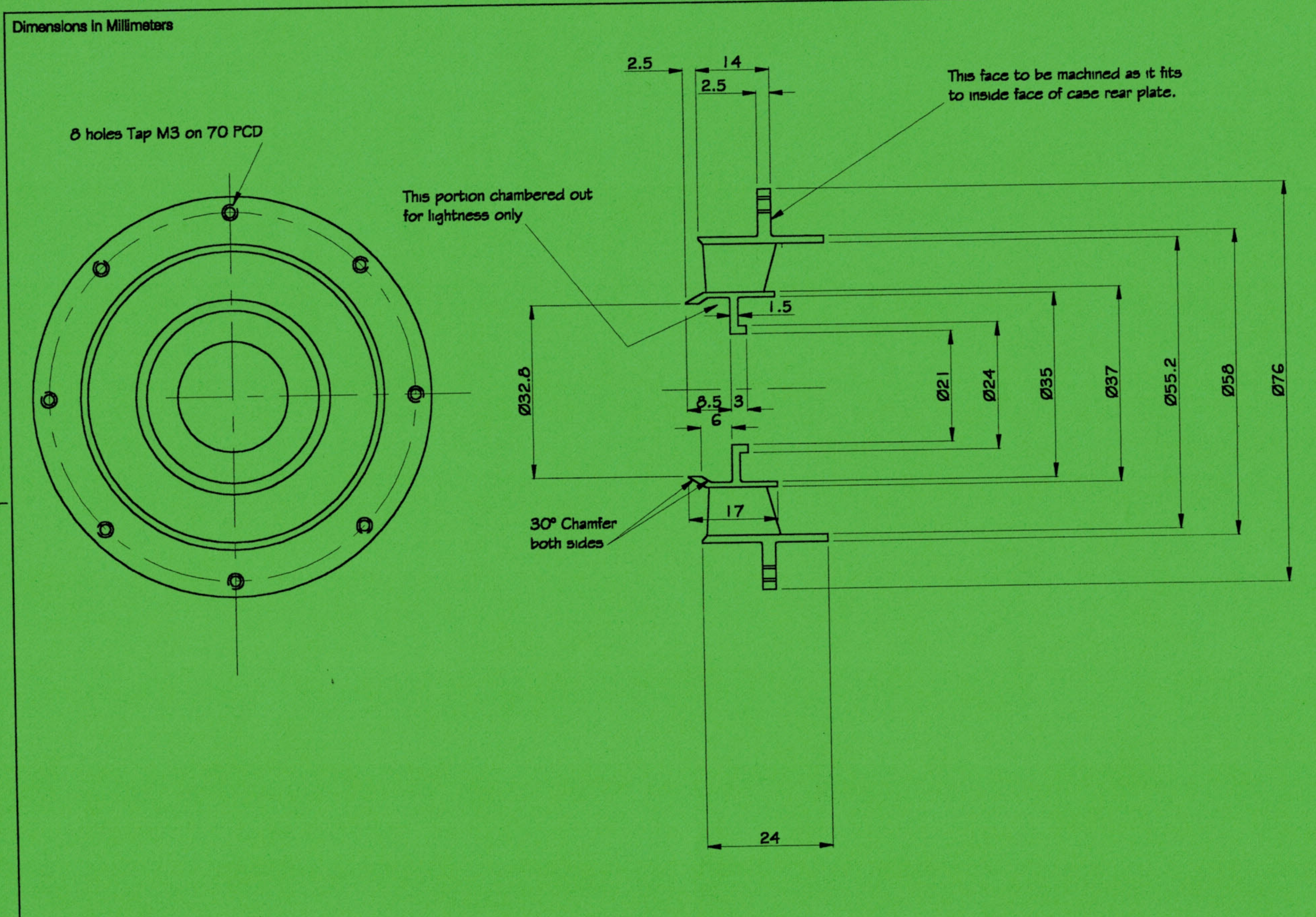




A Joints to be silver soldered.

Bend to finished shape on assembly.
Avoid covering air holes in chamber.

Fit suitable clips (spot welded to combustion chamber - if req.

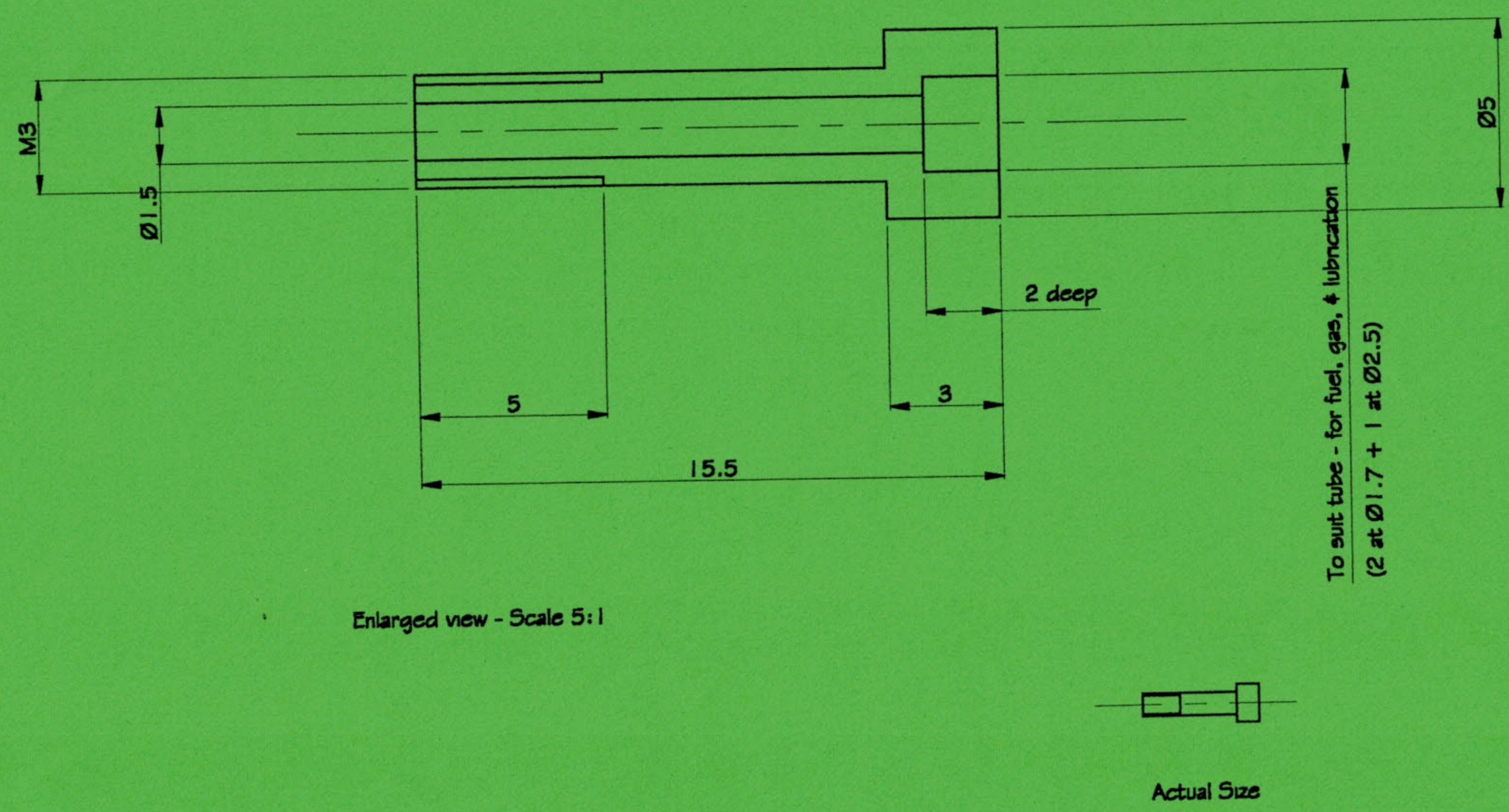
| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Brass/Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Gas Pipe | Issue: 2 | Part No. 034 |




Material:

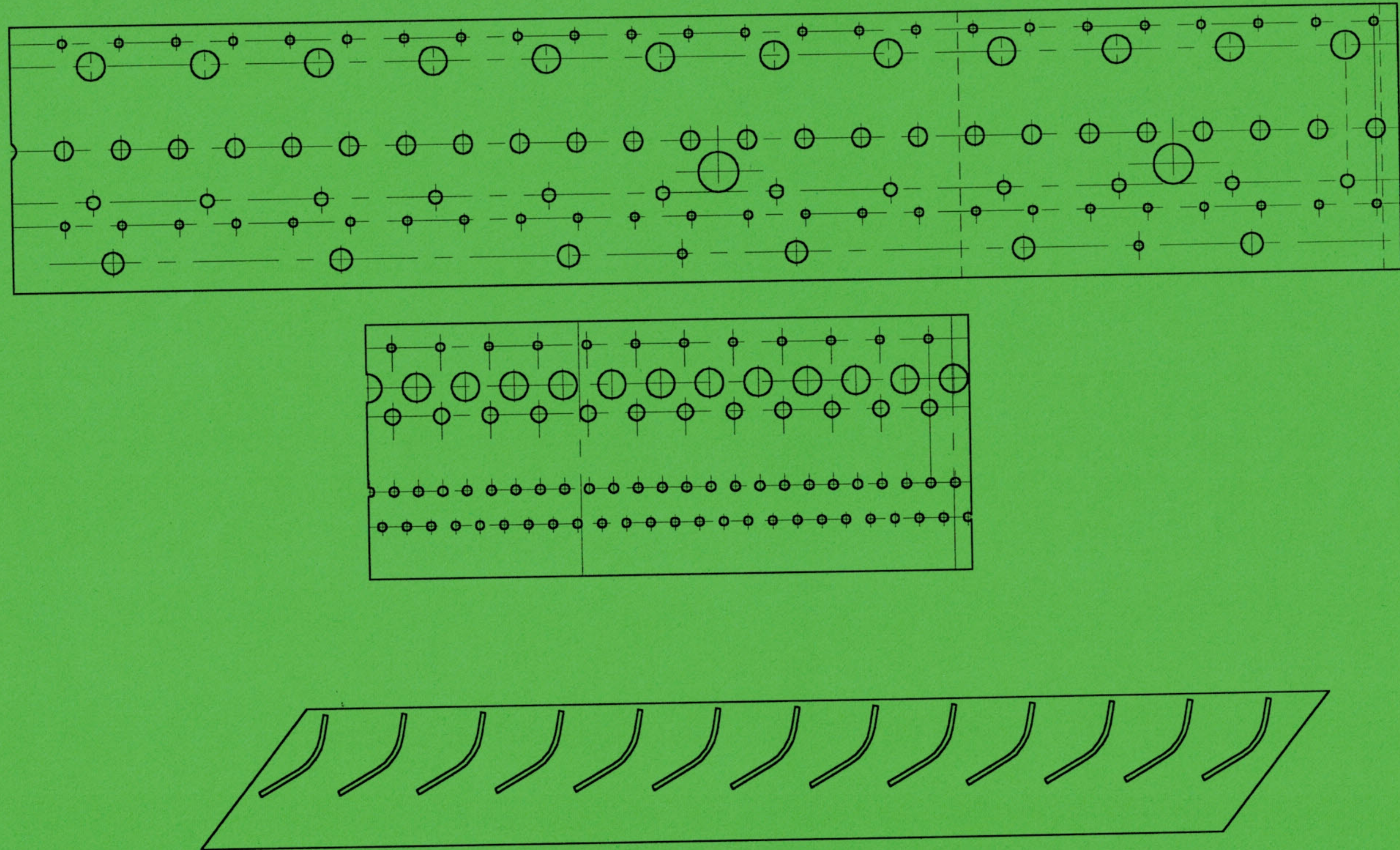
| | | | | | |
|---|---|---|---|---|---|
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Cast NGV - Machining | Issue: 2 | Part No. 035 |

Dimensions in Millimeters



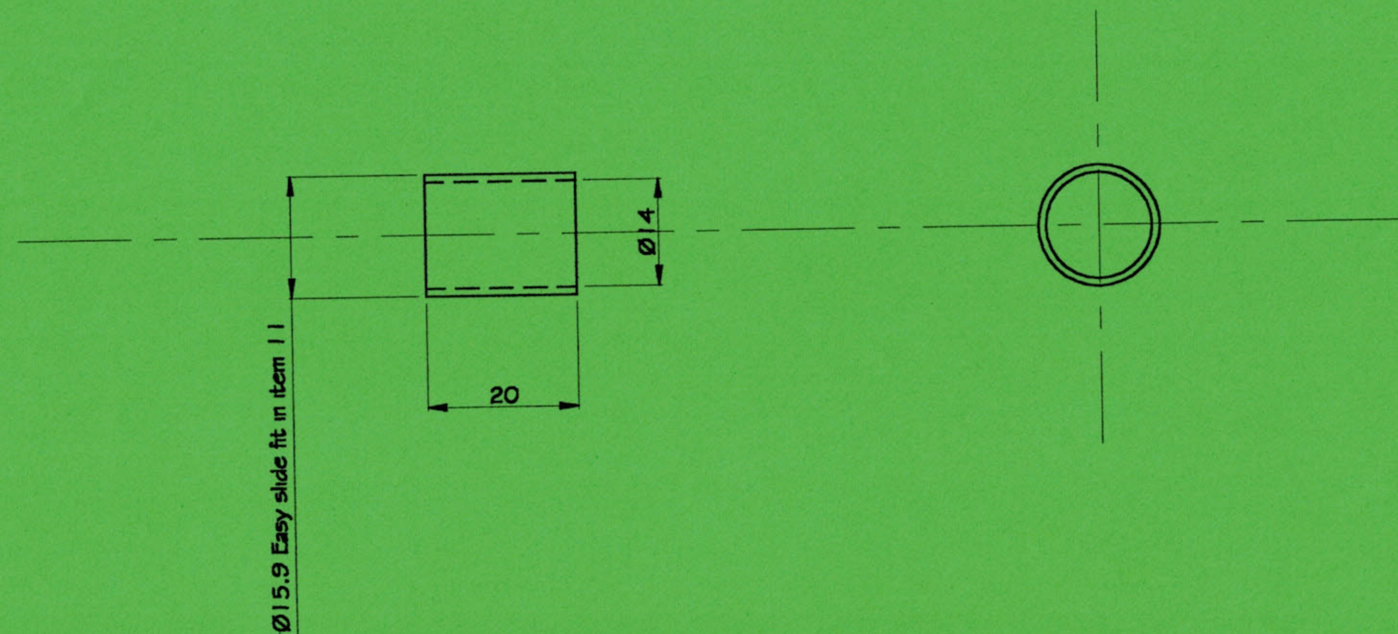

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Tube End Fitting | Issue: 3 | Part No. 036 |

Dimensions in Millimeters



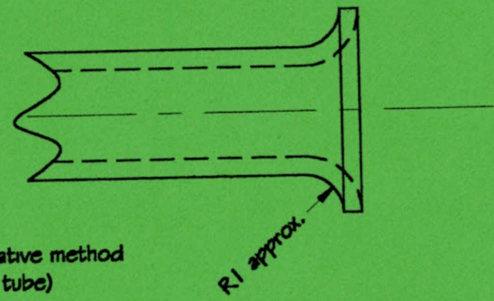
| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: See Details | | |
| Drawn: Terry Lee | Third Angle Projection | © Mike Murphy | Turbine - MW54 | Title: Templates | Issue: 1 | Part No. 037 |

Dimensions in Millimeters

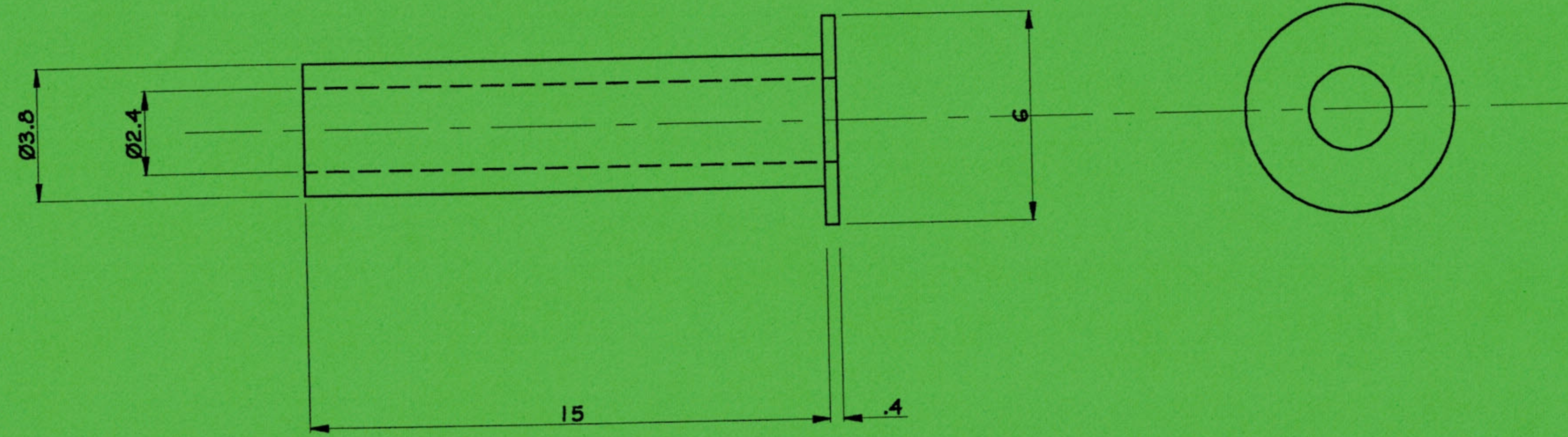



| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Mild steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Tube | Issue: 2 | Part No. 038 |

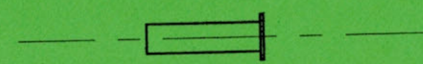
Dimensions in Millimeters




Alternative method
(using tube)




Enlarged view - Scale 5:1



Actual Size

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Material: Stainless Steel | | |
| Drawn: Terry Lee | Third Angle Projection | © WREN Turbines | Turbine - MW54 | Title: Swirl Jet | Issue: 2 | Part No. 039 |

**HND Aircraft Engineering Graded Unit 2**

| | |
|---|---|
| Name | **Thomas Dickinson** |
| Class Group | **F132A** |
| E-mail address | **s10195688@ayrshire.ac.uk** |
| Project Supervisor | **Tony Leslie** |
| Title of project | **Wren MW54** |
| Submission Date | **23.04.14** |
| Word count | **11296** |

**Please complete the checklist below to make sure you have completed all aspects of the assignment before you submit it for marking. Have you:**

| | |
|---|---|
| Included Introduction/Brief | ✔ |
| Included Project Specification | ✔ |
| Included Project Objectives | ✔ |
| Included Project Plan (GANTT Chart) | ✔ |
| Presented an appropriately referenced literature review | ✔ |
| Presented a detailed discussion/evaluation section | ✔ |
| Included a reflective account of project success | ✔ |
| Included Conclusion | ✔ |
| Included page numbers on every page | ✔ |
| Included the word count above | ✔ |
| Signed the declaration | ✔ |
| Included a correctly cited list references | ✔ |

**Declaration:** This assignment is a product of my own work.