Spring 2018

Garbage Disposal

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Senior Design Project Report

Garbage Disposal Project

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Project Ending Semester: Spring Semester

Date: April 16, 2018

Abstract:

The purpose of this report is to outline a new design for a sink garbage disposal system. The goal of this design is to develop a garbage disposal that could be made for less money, which would turn into a cost savings for the consumer and would lead to an increase in the amount of garbage disposal systems being used throughout the world. This allows the garbage disposal system to be marketed to different parts of the world that currently can't afford the systems available on the market.

The increased use of garbage disposals, help reduce the amount of organic material in landfills. This will reduce the amount of greenhouse gases emitted into the atmosphere, which would just be another step in the direction of helping preserve the planet.

This design utilizes a stack up of seven blades that spin on a shaft ran by a small, but high powered motor. The motor is attached on the side of the food chamber, to help protect it from the water and food that passes through the system. All of the parts would be injection molded if the design is taken to production, with the exception of the motor, seals, and fasteners. This design attaches to sinks different than the current models on the market. Rather than having the garbage disposal installed directly to the sink, it installs directly into the drainage pipes. This allows installation to be easier than the current market garbage disposals.

Overall, this report outlines a design for a garbage disposal system to be installed into the drain pipes, specifically under a sink. The design is compact and light, but still powerful. This allows the design to be a cost reduction for the manufacturing process, which will allow it to be marketed to consumers for less money.

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Chapter 1: Introduction

1.1) Background

The garbage disposal systems that is being focused on are the ones that typically are installed on a kitchen sink drain. This product allows small amounts of food scraps to go down the drain. Once the food scraps goes down the drain, it sits in a chamber until the unit is turned on and the garbage disposal will then break up the food scraps into small enough pieces so that it can pass down the drain safely, without the fear of it clogging up the pipes.

Garbage disposal systems are used in a large amount of households in the United States, but aren't often used in any other countries. The theory behind the garbage disposal systems isn't just to make clean up in the kitchen easier, although this was the initial thought. John W. Hammes developed the first garbage disposal system and was given a patent for his design. The patent can be found in Appendix A.

It has been found that food scraps cause numerous problems in landfills. Not only do organic material make up a large part of what ends up in landfills, when the organic material decomposes it produces methane gas, which contributes to the climate change known as global warming. Methane gas is a lot more potent than carbon dioxide, and does a lot more damage to the Earth's atmosphere. A garbage disposal system installed that allows those food scraps to be processed in water treatment plants can help keep a lot of organic material out of landfills. These plants are designed to capture the methane gas that is produced and turn it into energy instead of letting it escape into the atmosphere. They also can break down the organic material and turn it into biosolids that can be used as fertilizer (DoItYourself).

Although the use of garbage disposals, can increase your water and electrical consumption, it should be noted that this is a very small percentage of what you actually use. Water consumption increases by less than 1% and the total amount of electricity cost can be found to be totaling less than 50% (DoItYourself).

Garbage disposal systems do more than just assist with kitchen clean up. They can play a critical role in helping reduce the amount of landfills and can reduce the amount of methane gas that is released into the atmosphere. This will help with the continuing issue of global warming. Although this will not completely eliminate the production of greenhouse gases, every little bit will help slow down the effects of global warming, which is a huge environmental issue.

Our team wants to design a lower priced garbage disposal system that installs to a sink drain to market to areas of the world where people cannot afford current high priced garbage disposal units. This will increase the ability of garbage disposal system to be used so that it will help affect the negative effects that decomposing organic materials have on our environment. In order to accomplish this, many different avenues were researched. This includes the use of different materials, different motors to use, different methods of power, the use of different grinding methods, and different installation methods.

1.2) Product Definition

The design of the garbage disposal system needs to be able to be produced cheaper, but still as effective as the designs currently on the market. In order to do that, a combination of different materials, different sources of power, different motors, different methods of grinding, and different modes of installation need to be utilized.

The use of different material is the key to a lot of the other money saving elements of the design. In order to make most of the cost savings, lighter and cheaper materials need to be found. The materials will also have to be able to withstand the water and food and hold up as long as the garbage disposal components currently being utilized in the current designs.

The power source needs to be taken into account when designing the system. All current models, utilize wiring the garbage disposal to a light switch in order to power the motor. It needs to be decided if it is believed to still be the best method for obtaining power, or is there something different that can be done to power the motor that would be more cost effective. One method that is going to be researched is having the garbage disposal system be completely contained without needing outside power.

The motor needs to be addressed when designing the new system. It is believed that a garbage disposal will still be able to be just as effective using a cheaper, lighter, and less powerful motor, like the motors that can be found in a blender. Essentially a blender and our system is going to be rather similar, because essentially they have a very similar function. That is to take solid food, and grind it down into smaller pieces. These motors can be found for relatively cheap in comparison to the motors that are currently being used in the different garbage disposal systems. Although the larger and more powerful motors can be useful, their disadvantages and advantages are going to be explored.

For current garbage disposal systems, a blade rotates on a flat plate with holes in it, so that food scraps that aren't small enough to pass through the pipe system, don't get into the pipes. In order to make the system cheaper, this method needs to be explored. Although this method works, it needs to be determined if there is a way that the same end result can be accomplished more efficiently and more cost effective. One method that is going to be explored

is designing something that resembles a shredder. There would be more blades, which may be more weight, but this may be a lot more efficient way to grind up the food scraps.

Garbage disposals are designed with an entirely different sink adapter than just a regular sink drain. This adds to the cost for materials, manufacturing costs, and complexity of installation. Though there are specific advantages to using this design, the thought is that there is a better way to design the garbage disposal so that this adapter isn't necessary and the garbage disposal system can just be installed straight into the current drainage pipe instead of attaching it to the sink.

Chapter 2: Conceptual Design

2.1) Preliminary Design Brief

The purpose of this design is to develop a garbage disposal system that is going to be installed for use with a kitchen sink. There are numerous current designs already on the market with various patents, but the goal is to develop a design that allows a garbage disposal system to be purchased for cheaper than the ones currently being sold. While the garbage disposal needs to have a cheaper purchase price, the quality needs to remain the same or even approve upon the current designs.

Although there are probably ways to save money in the current manufacturing methods of the current models, the focus of this report is to develop an entirely new system. In order to cut down on the costs a combination of different materials, different sources of power, different motors, different methods of grinding, and different modes of installation need to be utilized.

2.2) Expanded Design Brief

Garbage Disposals are made up of various different components, and each component could provide with a cost saving element. The main elements of the system is the motor, power source, housing, drainage, sink adaptor, and impellers. These elements can be seen in Figure 1, though it should be noted that the sink adaptor is shown but not labeled.

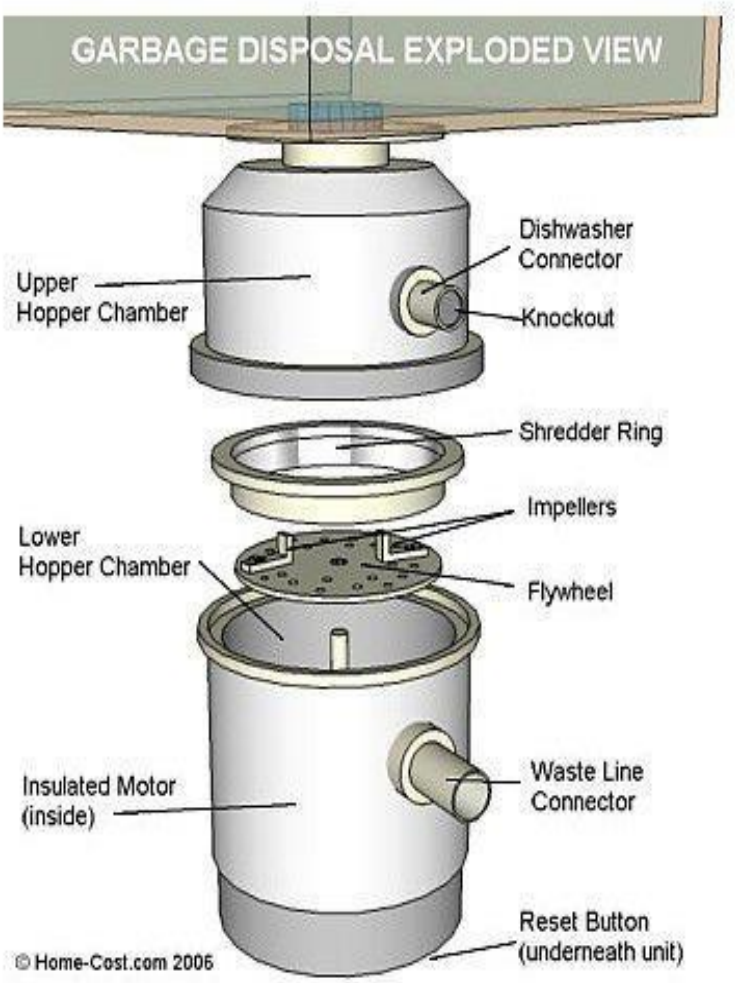


Figure 1: General Garbage Disposal Exploded View

The upper housing, or hopper chamber as labeled in Figure 1, is the main chamber where the food scraps gather. As water goes down the drain, it goes through this chamber and out the drain. The food scraps go into this hopper as well, but they build up in the hopper until the garbage disposal system is turned on.

The impellers are what break up the food scraps. They are attached to the motor, which spins the impellers. The impact of the food with the impellers is what breaks them up into small enough pieces to safely pass through the drainage pipes and to the water treatment centers.

The flywheel serves as a filter for the food scraps, so that nothing bigger than what can pass through the pipes makes its way into the pipes.

The waste line connector is what connects the garbage disposal chamber to the drain pipes. This is what the waste water and broken up food scraps go through to exit the garbage disposal system and make their way to the water treatment centers.

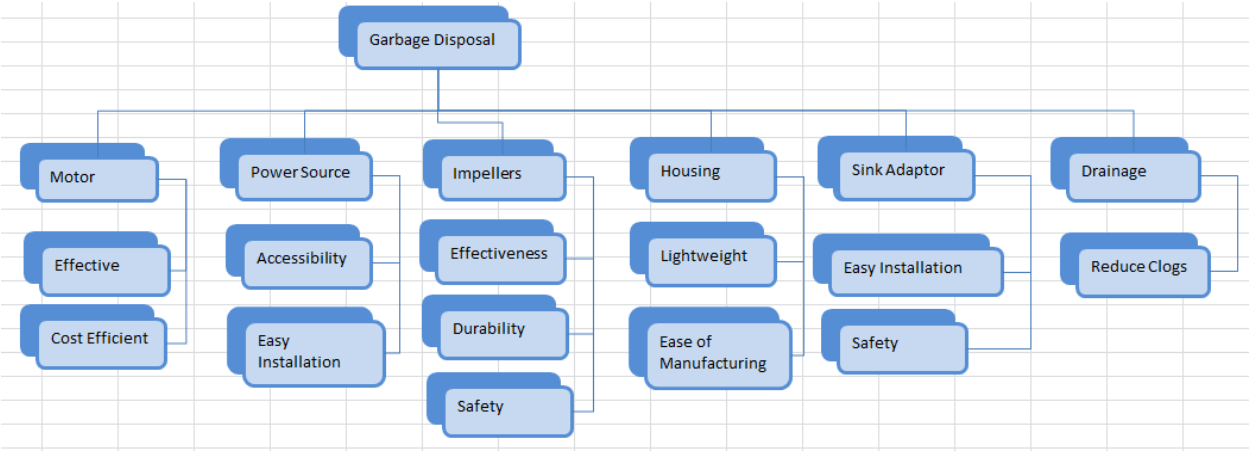
The sink adapter is what is attached to the sink in order to allow for installation of the garbage disposal. Every garbage disposal on the market uses a very similar installation system. A specific drain is inserted into the sink and then the garbage disposal clamps onto the sink and the drain. This means that the sink supports the weight of the garbage disposal.

The lower housing, or hopper chamber as it is labeled in Figure 1, is where the motor is stored. The motor is typically in its own housing inside of the chamber to ensure that no water can get to the motor.

2.3) Design Development

To better define the different components of a garbage disposal, an objective tree was developed. An objective tree breaks down the final design into its various components and then defines the importance of those different components. The garbage disposal system is broken down into six main components. Those components are the motor, power source, impellers, housing, sink adaptor, and drainage. The objective tree that was developed is shown in Figure 2. This clearly defines what the goal of the final design is.

Figure 2: Objective Tree



In order to organize design ideas that were thought of, a morphological chart was developed. This allowed the key components from the objective tree to be documented. With every component, multiple ideas were documented that could help improve that component to meet the design needs. In Table 1, the concept generation that was done is documented.

Function	1	2	3	4
Power	battery pack	house electricity	self-contained power	
Motor	same power and torque but smaller size	less powerful motor	blender motor	fully contained motor
Impellers	3D printed	shredder	multiple impellers	stationary impellers on housing
Sink Adaptor	make more simple	connect to drainage pipe	cheaper materials	
Drainage	vertical drain	horizontal drain	screen covering	
Housing	injection molded	one housing	two separate housings	

Table 1: Morphological Chart

To better picture the different possibilities quick sketches were made of the various design options. A lot of different ideas for the impellers varied the most that can't be seen in morphological chart. These weren't included in the morphological chart because they all have the same general functionality.

In order to narrow down the possibilities a decision matrix was developed. A decision matrix takes design requirements and weighs them on a scale based upon their importance to the design requirements. It then takes the different design options and implements them into that weighted scale to decide which design is the best option to pursue. The weighted decision matrix, found in Table 2, shows that Option C is the best option to develop for the needs of the design requirements. Only a sample of the different design options is shown below.

Table 2: Weighted Decision Matrix

	3	2	2	1	0.5	8.5
	35%	24%	24%	12%	6%	100%
Option	**Cost**	**Functionality**	**Safety**	**Installation Ease**	**Durability**	**Score**
Option A	3	5	6	5	7	5
Option B	2	6	6	5	6	4
Option C	6	7	7	8	6	7

Option A: battery pack, multiple impellers, two housing, less powerful motor, same sink adaptation, metal parts

Option B: battery pack, shredder, single housing, self contained motor, same sink adaption, 3D printed parts

Option C: light switch power, shredder, two housing, blender motor, 3D printed parts, attach to pipes not sink

Chapter 3: Embodiment Design

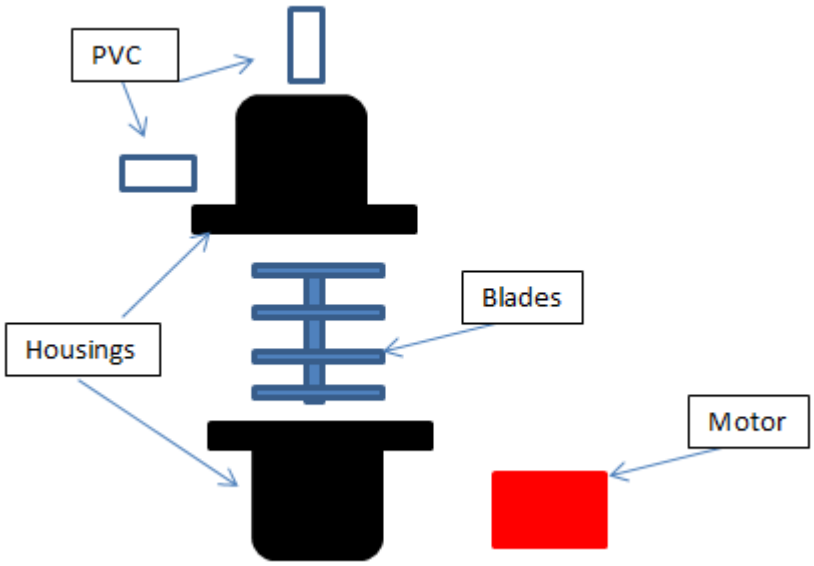


Figure 3: Simplified Design Drawing

In order to incorporate the various design elements we decided to use two separate housings and bolt them together. The top compartment holds the blades that spin and chop up the food. The second compartment is to keep the 90 degree gears from being interfered with. There is a rotary seal bearing that comes out the side of the housing that is connected to the motor.

The blade housing has a connection molded into the top of it to connect to existing drain pipes, and to drain the water out of the system. These connections are design for 1 ½" Standard PVC pipe which is typical to use in standard sink drains. There is a rotary seal that keeps the water out of the gears.

In order to mount the motor, we had to develop a hanger. This hanger attaches to the flange of the housing connections in order to cut down on the moment that is created by attaching the motor to the side of the system instead of directly underneath the system as is typical in current designs.

$$\text{Moment} = \text{Force} \times \text{Distance}$$

In order the get the garbage disposal made for less money the motor was the biggest obstacle. The motor needs to have the necessary RPM in order to effectively chop up the food. The best way that was found to achieve this was to incorporate a cheap motor that can be found in typical blenders. Current sink garbage disposal systems use a motor that spins at 1790 RPM, in order to have an effective garbage disposal system the motor needs to be able to better or match that RPM.

$$\text{Torque} = \text{Force} \times \text{RPM}$$

Material selection is also a key aspect in making a cheaper and lighter garbage disposal. For prototyping purposes all of the parts would be 3D printed utilizing ABS plastic. This was the most effective way for prototyping. For production purposes, the housing, blades and shafts should be injection molded. The hanger should be made up of sheet metal aluminum. All these materials are relatively light, won't rust when coming into contact with water, and cheap to manufacture.

Essentially, this design would be mounted to the drainage system instead of to the sink directly. The food and water would come into the blade housing where the blades will break up the food and then the water and food would continue out the exit drain. The blades are connected to the motor by a pair of 90 degree gears, and the shafts on through the housing walls by utilizing a few rotary seal bearings.

The most likely mode of failure would be leaking from the drainage pipes. The top connecting pipe is going to experience the greatest moment. This connection is fastened with PVC glue. The motor is connected to a shaft that connects to the gears. The gears and motor shaft are epoxied to each other. This is another possible source of failure, although with strong enough epoxy, it is an unlikely one.

Chapter 4: Detail Design

This design has two main loads. The load caused by the weight of the design, and the moment cause by the motor being attached to the side of the housing. The weight of the garbage disposal has to be light enough so that it doesn't want to pull itself out of the drainage pipe. We developed a hanger that mounts to the center of the garbage disposal that mounts to the motor to reduce the moment of the motor acting on the pipes. This is why the weight of our materials is so crucial to the success of this design.

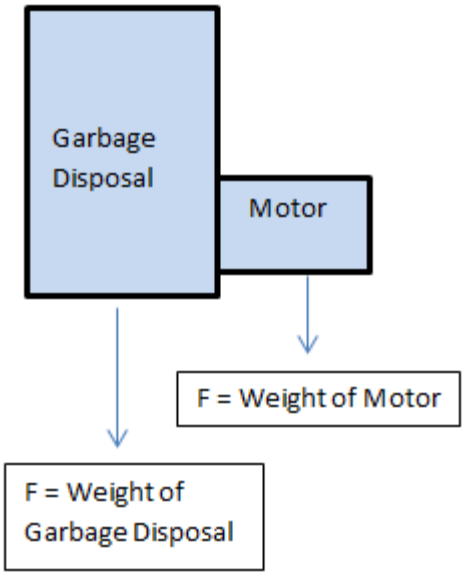


Figure 4: Free Body Diagram without Designed Hanger

Moment = (3.6")(1.2lb) = 4.32 in x lbs

As shown in Figure 4, it can be seen that the motor causes a moment on the garbage disposal because it is attached to the side of the garbage disposal, instead of having its center of mass in line with the center of mass with the garbage disposal. In order to reduce this moment, a hanger was designed so that the force of the weight of the motor can be brought closer to the center of mass of the rest of the garbage disposal system. Although, this doesn't eliminate the entire cause moment, it decreases it by 41%. This is shown in Figure 5.

Moment = (1.2lb)(1.5") = 1.8 in x lbs

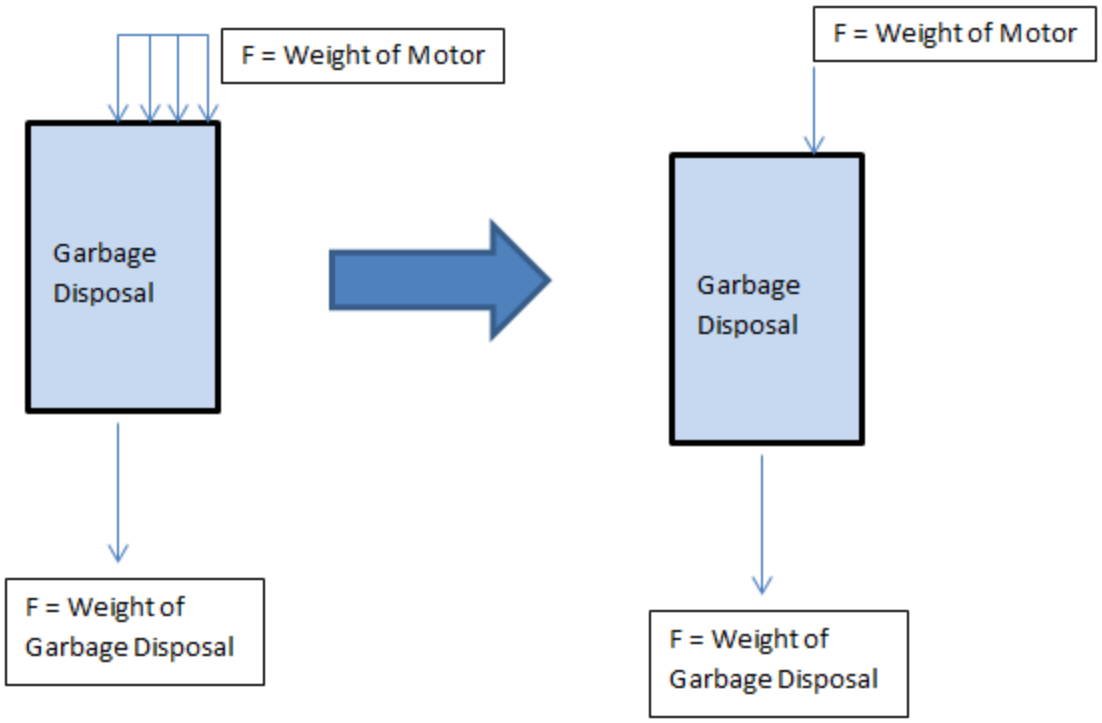


Figure 5: Free Body Diagram with Hanger

A few of our components were standard components that were ordered for use in our design. The motor that we ordered was actually a motor that was taken out of a blender, because this was the cheapest option for prototyping. It is a standard 110 V, 300 Watt, with 23,000 RPM. This allows us to have a very small and light, but very powerful motor (Epica).

The fasteners that we used to hold the two separate housings together were standard # 10 bolts that are an inch in length with a nut. We also use these fasteners to attach the blades to the spinning shaft.

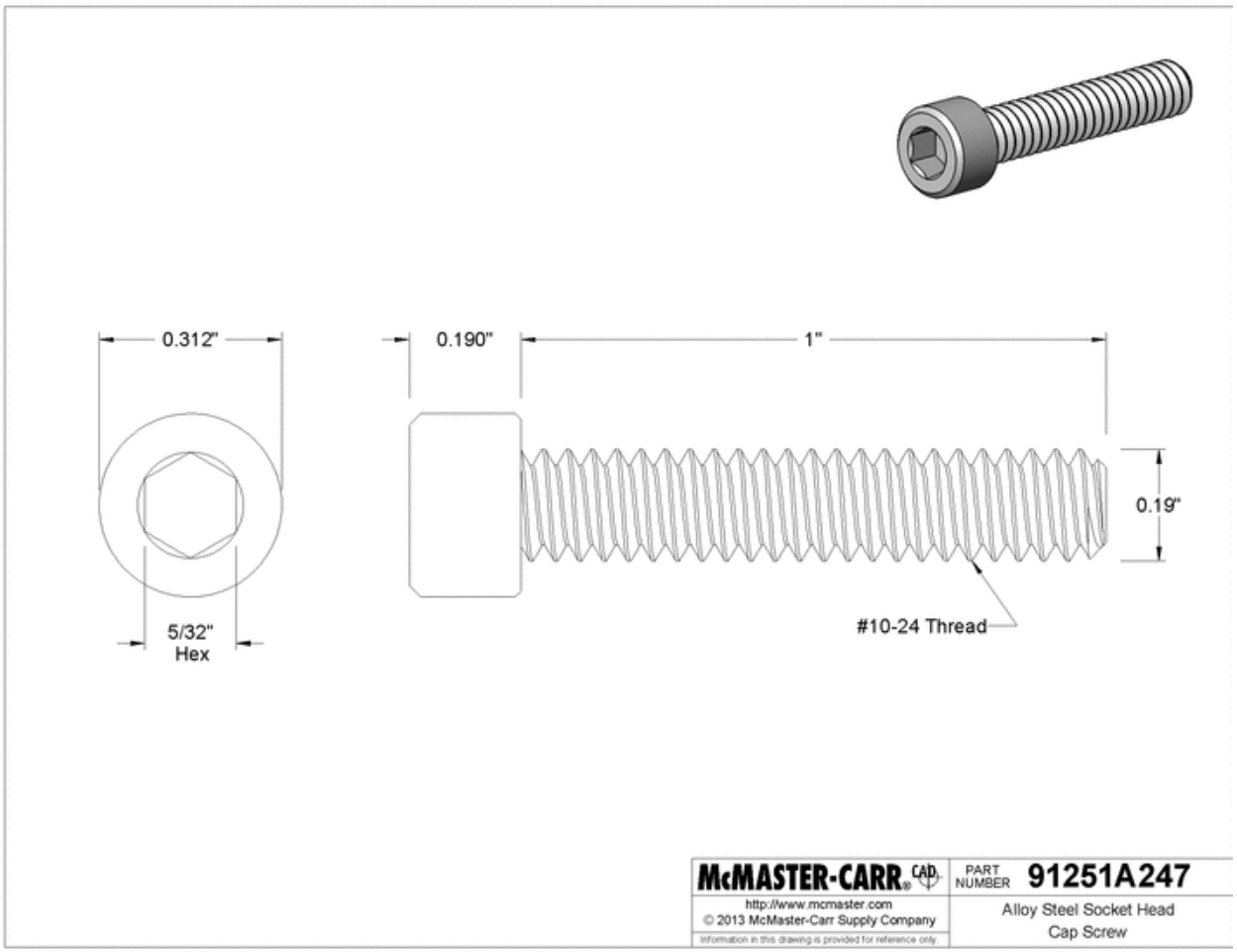


Figure 6: Drawing of Bolts

Thread Size	10-24
Length	1"
Threading	Fully Threaded
Head Diameter	0.312"
Head Height	0.19"
Drive Size	5/32"
Material	Black-Oxide Alloy Steel
Hardness	Rockwell C37
Tensile Strength	170,000 psi
Screw Size Decimal Equivalent	0.190"
Thread Type	UNC
Thread Spacing	Coarse
Thread Fit	Class 3A
Thread Direction	Right Hand
Head Type	Socket
Socket Head Profile	Standard
Drive Style	Hex
Specifications Met	ASTM A574
System of Measurement	Inch
RoHS	Compliant

Figure 7 : Specifications of Bolts

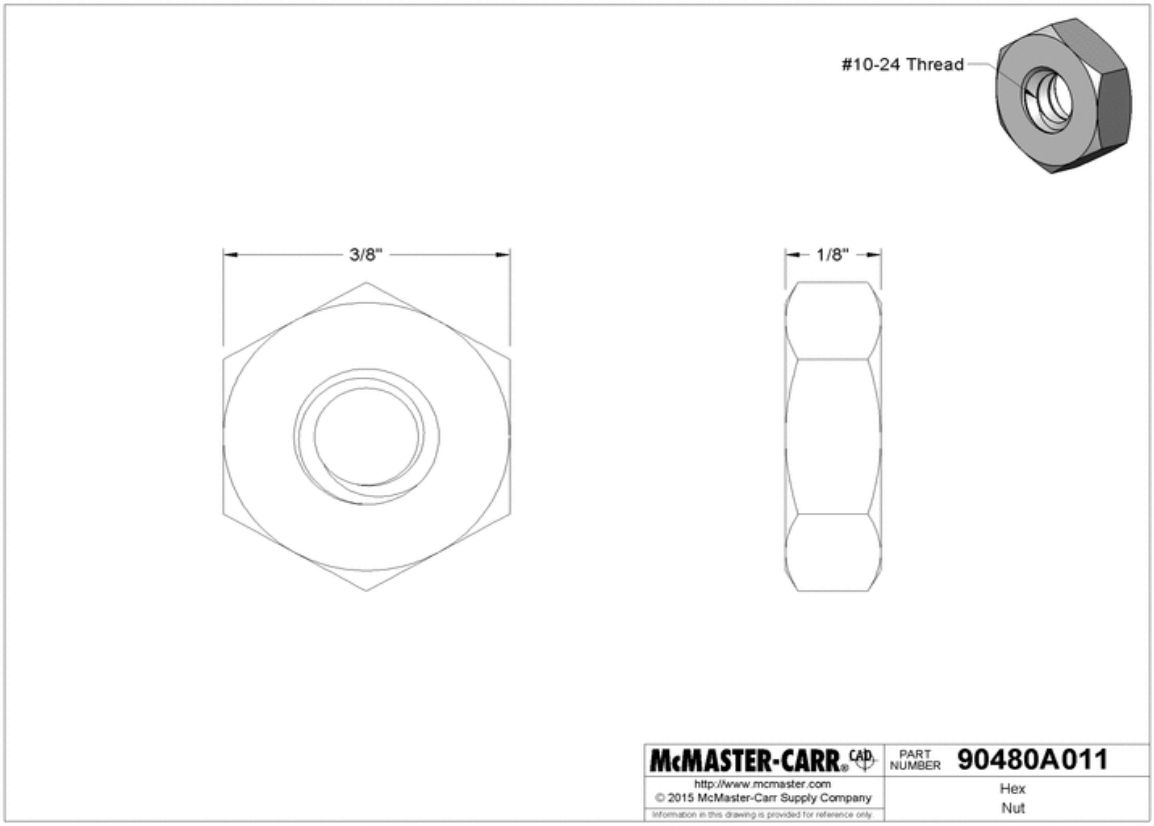


Figure 8: Drawing of Nut

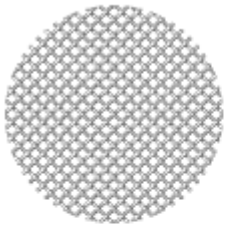
Material	Zinc-Plated Steel
Thread Size	10-24
Thread Type	UNC
Thread Spacing	Coarse
Thread Fit	Class 2B
Thread Direction	Right Hand
Width	3/8"
Height	1/8"
Drive Style	External Hex
Nut Type	Hex
Hex Nut Profile	Standard
System of Measurement	Inch
RoHS	Compliant

Figure 9: Specifications of Nut

In order to keep food that hasn't been broken up from getting into the drain, a piece of wire mesh is epoxied to the drain opening. This was also a standard part that was ordered. The specifications can be seen in Figure 10.

304 Stainless Steel Wire Cloth Discs

1-7/8" Diameter, 20 x 20 Mesh Size



Packs of 25

ADD TO ORDER

In stock
$9.99 per pack
9317T164

Shape	Disc
Construction	Woven
Material	304 Stainless Steel
Diameter	1 7/8"
Mesh Size	20 × 20
Opening Size	0.034"
Open Area	46%
Wire Diameter	0.016"
RoHS	Compliant

Figure 10: Wire Mesh Specifications

In order to keep water away from the motor and gears, a couple rotary seals were needed to be incorporated in the design. These seals are designed to attach to rotating shafts and keep water out.

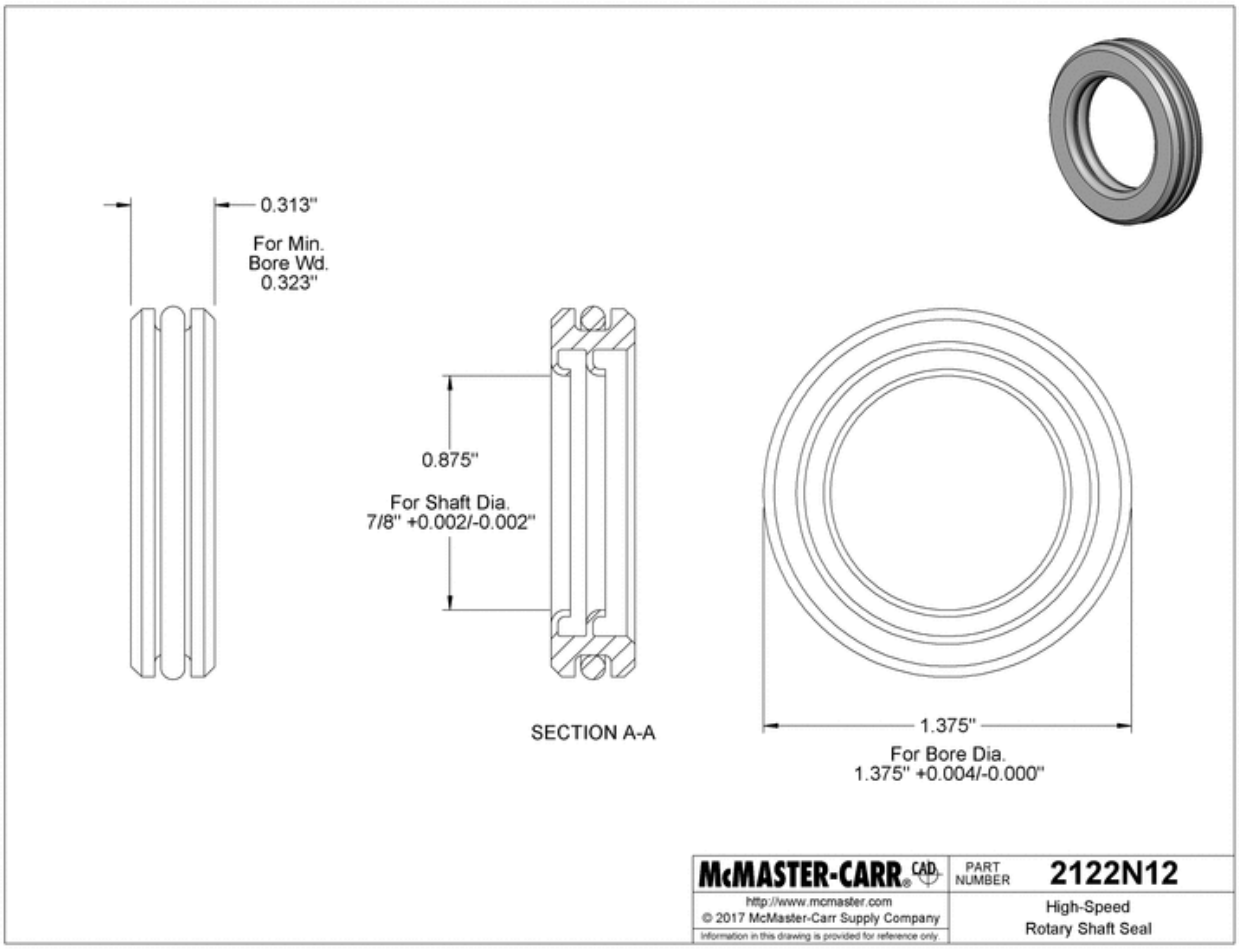
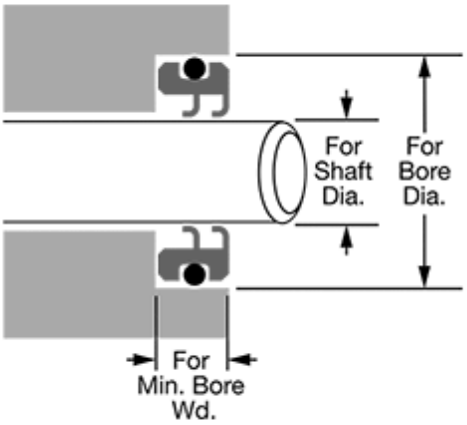


Figure 11: High Speed Rotary Shaft Seal Drawing

High-Speed Rotary Shaft Seal

for 7/8" Shaft Diameter



Each

ADD TO ORDER

Ships in 1–2 weeks
$30.26 Each
2122N12

For Motion Type	Rotary
Material	PTFE Plastic
Filler Material	Graphite
For Sealing	Shafts
For Shaft Diameter	7/8"
For Bore	
Diameter	1.375"
Min. Width	0.323"
Seal	
ID	0.875"
OD	1.375"
Width	0.313"
Maximum Speed	21,800 rpm
Maximum Pressure	150 psi
Temperature Range	-40° to 250° F
Hardness	Durometer 60D (Extra Hard)
Color	Black
Loader Type	O-Ring
O-Ring	
Material	Buna-N Rubber
Hardness	Durometer 70A (Hard)
Color	Black
For Use With	Animal Oils Boric Acid Calcium Hydroxide Citric Acid

Figure 12: Schematics of High Speed Rotary Shaft Seal

Epoxy was used to attach the mesh filter to the housing, and to attach the motor shaft to the gears. The epoxy is a standard 2 part high strength adhesive. The specifications can be found in Figure 13.

Container	
Size	8 oz.
Type	Bottle
Begins to Harden	3 hrs.
Reaches Full Strength	24 hrs.
Mixing Required	Yes
Mix Ratio	1:1
Temperature Range	-65° to 250° F
Color	Gray
Clarity	Opaque
For Use On	Aluminum, Brass, Bronze, Copper, Steel, Stainless Steel, Cast Iron, Titanium, Vinyl Plastic, EPDM Rubber, SBR Rubber, Glass, Concrete
Additional Specifications	SDS
RoHS	Compliant

Form strong vibration- and peel-resistant bonds with these two-part adhesives. The size listed is the combined total of the two parts. Epoxies are the strongest and most weather- and chemical-resistant structural adhesives. Surface preparation is required.

Figure 13: Epoxy Specifications

In order to be able to mount the motor on the side of the housings, an adaption had to be added in order to change the rotation from being in the horizontal plane to being in the vertical plane. This was achieved by using a set of 90 degree gears.

Boston Gear

Boston Gear GP1632Y Miter Gear, 0.500" Bore, 1:1 Ratio, 20 degree Pressure Angle, 16 Pitch, 32 Teeth, Molded Nylon

12 customer reviews | 5 answered questions

Price: $21.95 prime

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Specifications for this item

Part Number	GP1632Y
UPC	781711541050
Measurement System	Inch
Number of Teeth	32
Bore Diameter	0.500 inches
Brand Name	Boston Gear

EAN	0781711541050
Face Width	0.390 inches
Material	Nylon
Number of Items	1
Pitch	16 unknown_modifier

Figure 14: Gear Specifications

The total cost for the prototype of this machine totals approximately $241.92. The breakdown of the cost of the different parts can be found in Table 3 below. This isn't as cheap as the design specifications wanted, however if this is put into production various parts will be a lot cheaper because of the ability to buy in bulk. Specifically, the motor, gears, epoxy, and rotary seal would be able to be bought for cheaper in bulk rather than just buy 1 or 2 a piece. Also, all the main components we got 3D printed for prototyping purposes and once this design goes to production the parts would then be injection molded, which is a lot cheaper than 3D printing.

Table 3: Cost Analysis

Component	Cost	Amount	QTY	Final Cost
Epoxy	$20.02	16 oz		$20.02
Rotary Seal	$30.26	1	2	$60.52
Wire Mesh	$9.99	25	1	$0.40
Motor	$30.00	1	1	$30.00
Bolt #10 - 1"	$8.29	50	14	$2.32
Nut	$1.84	100	14	$0.26
Gears	$21.95	1	2	$43.90
3D Printed Parts	$84.50			$84.50
				$241.92

Table 4: Bill of Materials

Component	Quantity
Epoxy	1
Rotary Seal	2
Wire Mesh	1
Motor	1
Bolt	14
Nut	14
Gears	2
Blades	7
Blade Housing	1
Shaft	1
Motor Housing	1
Motor Connector	1
Motor Hanger	1
Motor Separator	1

Any detailed drawings that were designed specifically for this project can be found in Appendix B and C. This includes the various assembly drawings

Chapter 5: Discussions

Our design, like any other, will need optimized. Due to delays in 3D printing, there was no time to complete multiple iterations of our design. Major design components such as the motor and blades could be designed and ordered to custom specifications in a mass production setting. Additionally dies could be built for injection mold the plastic components, further reducing cost if enough units could be sold. Time for market research would have allowed us to setup a survey and see what the actual market for consumers looks like, their locations, average price they would be willing to spend, and if they are capable of the type of installation we consider being "simple". All of these are points for improvement given more time and resources.

Chapter 6: Conclusions

Given our combined available resources for the group, we consider our project to be a success. We came up with a prototype model that is still in the price range of currently available garbage disposals, despite using some of the most expensive manufacturing techniques available. With further development the function and price point could easily be improved to make a very competitive product.

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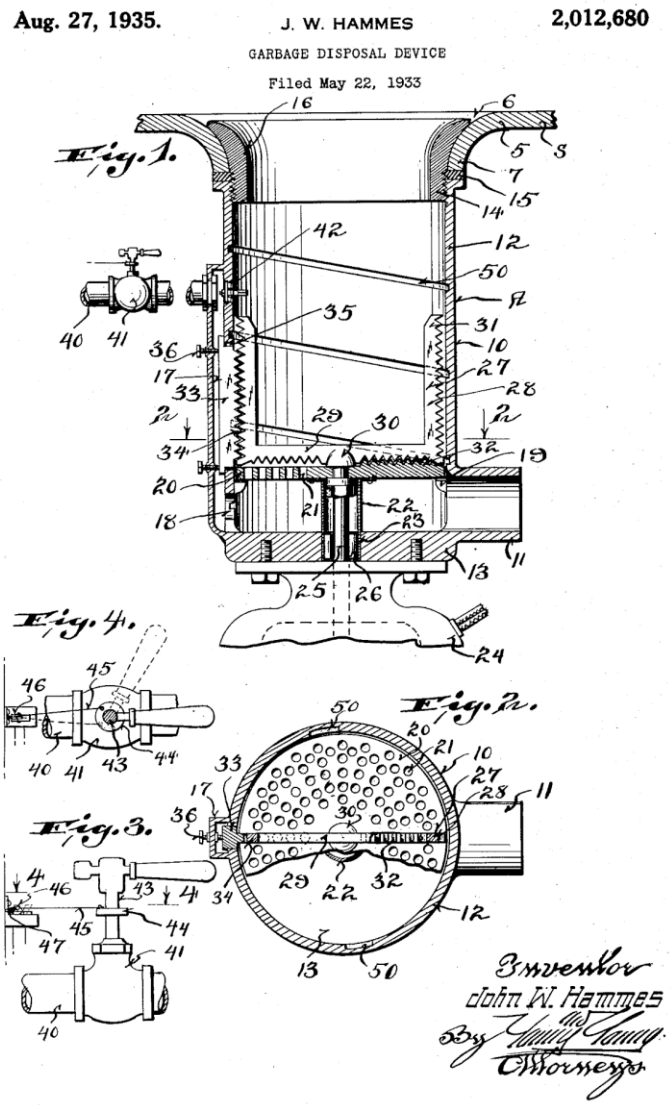
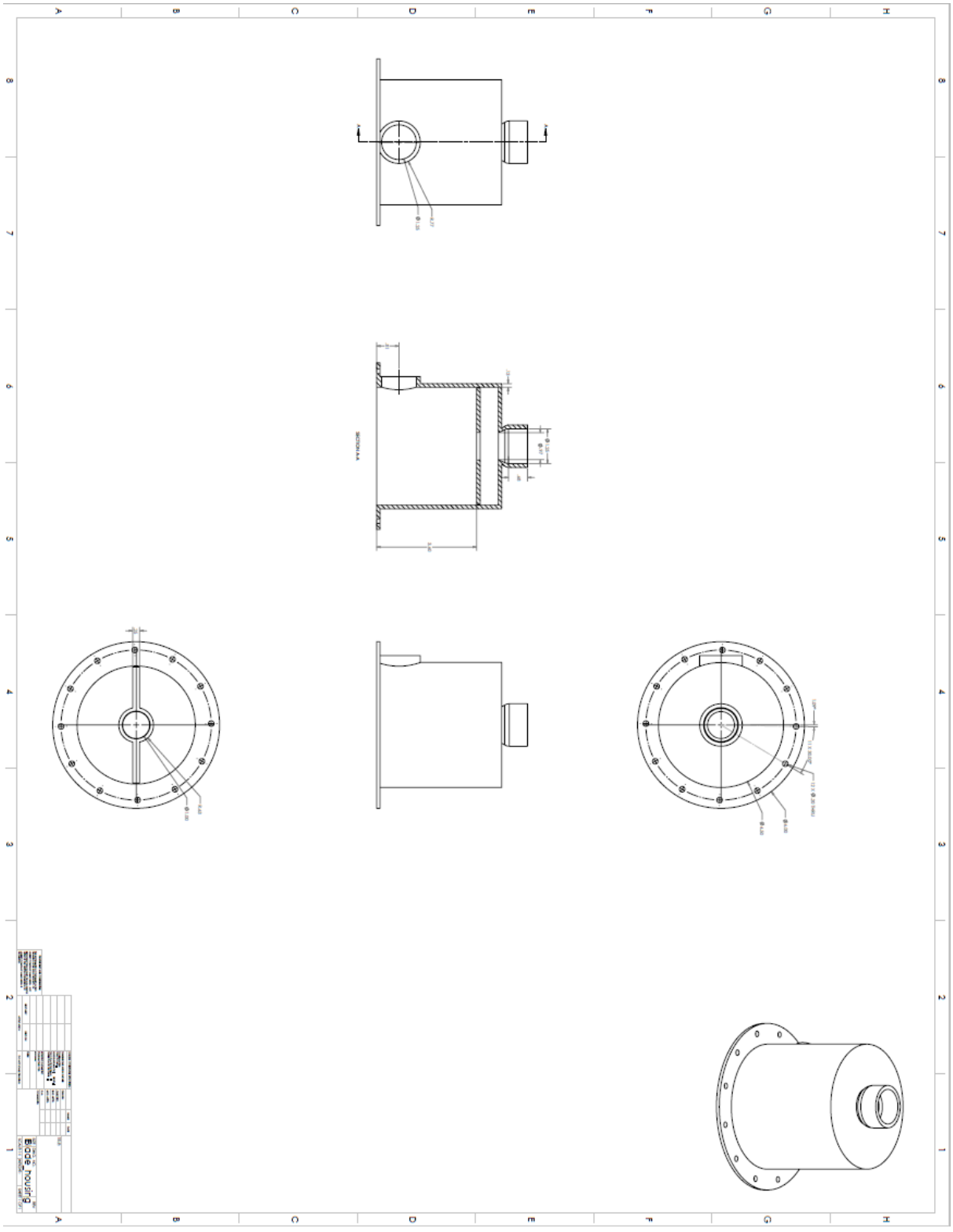
Appendices:

Appendix A: Existing Patent

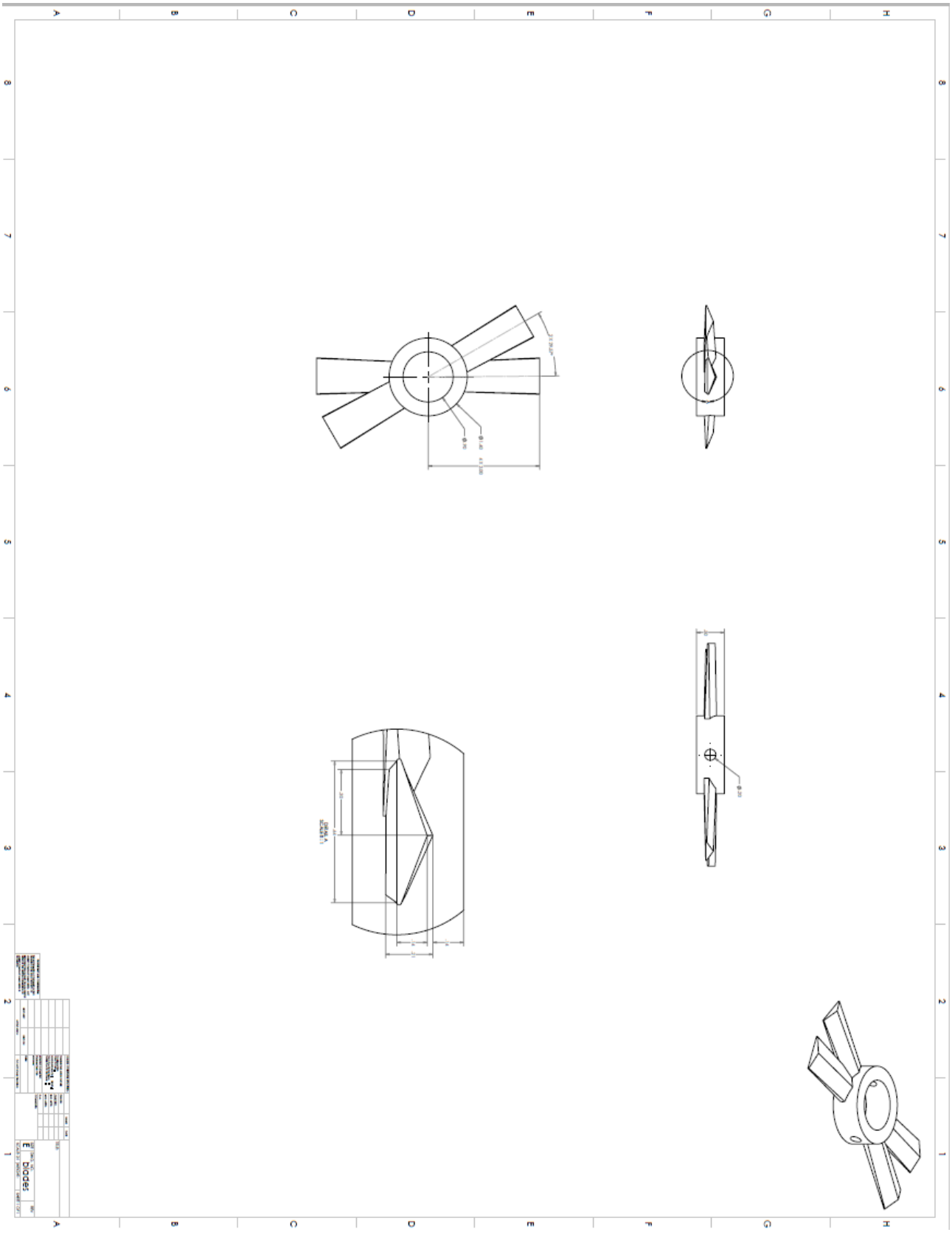


Appendix B: Part Drawings

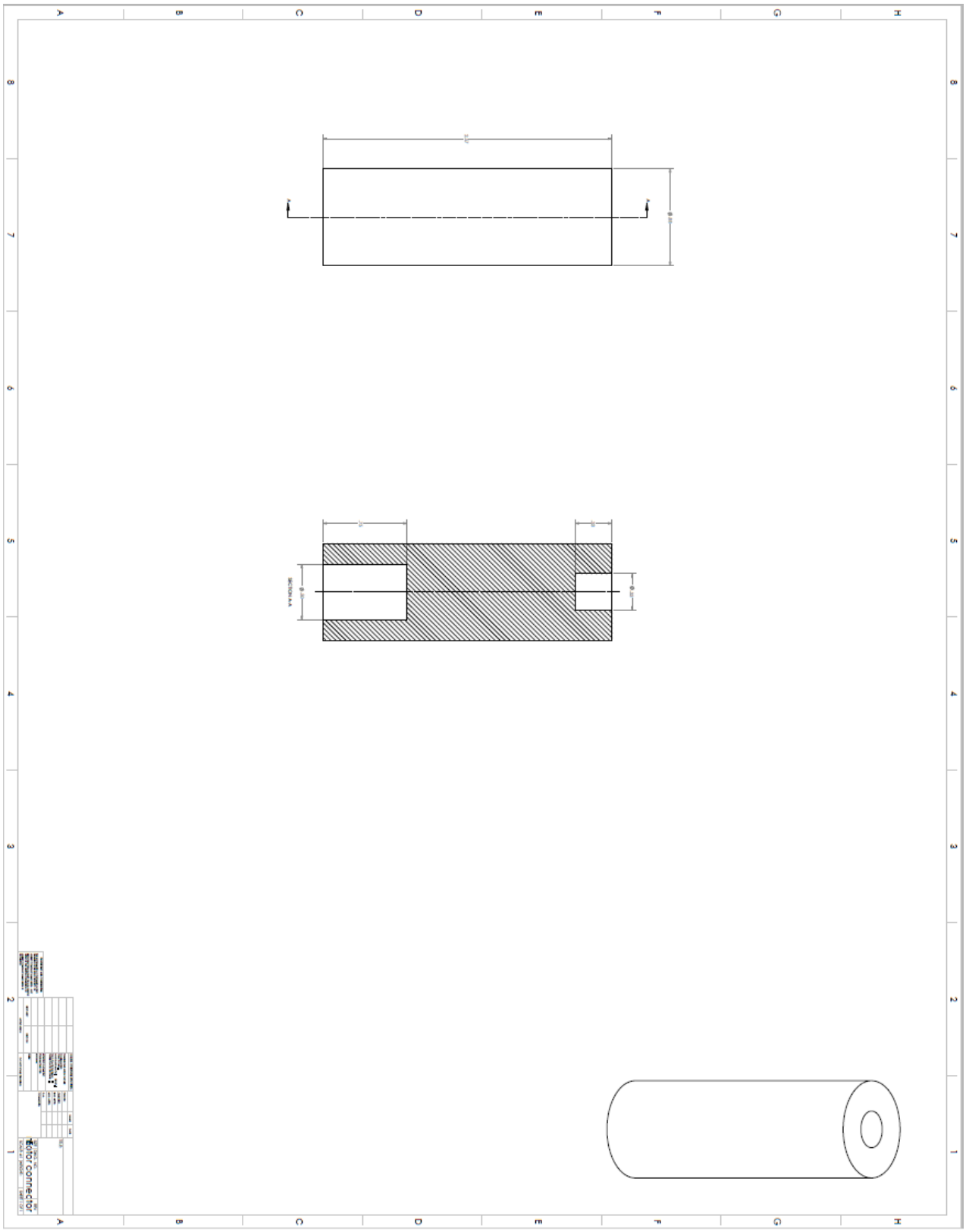
Blade Housing



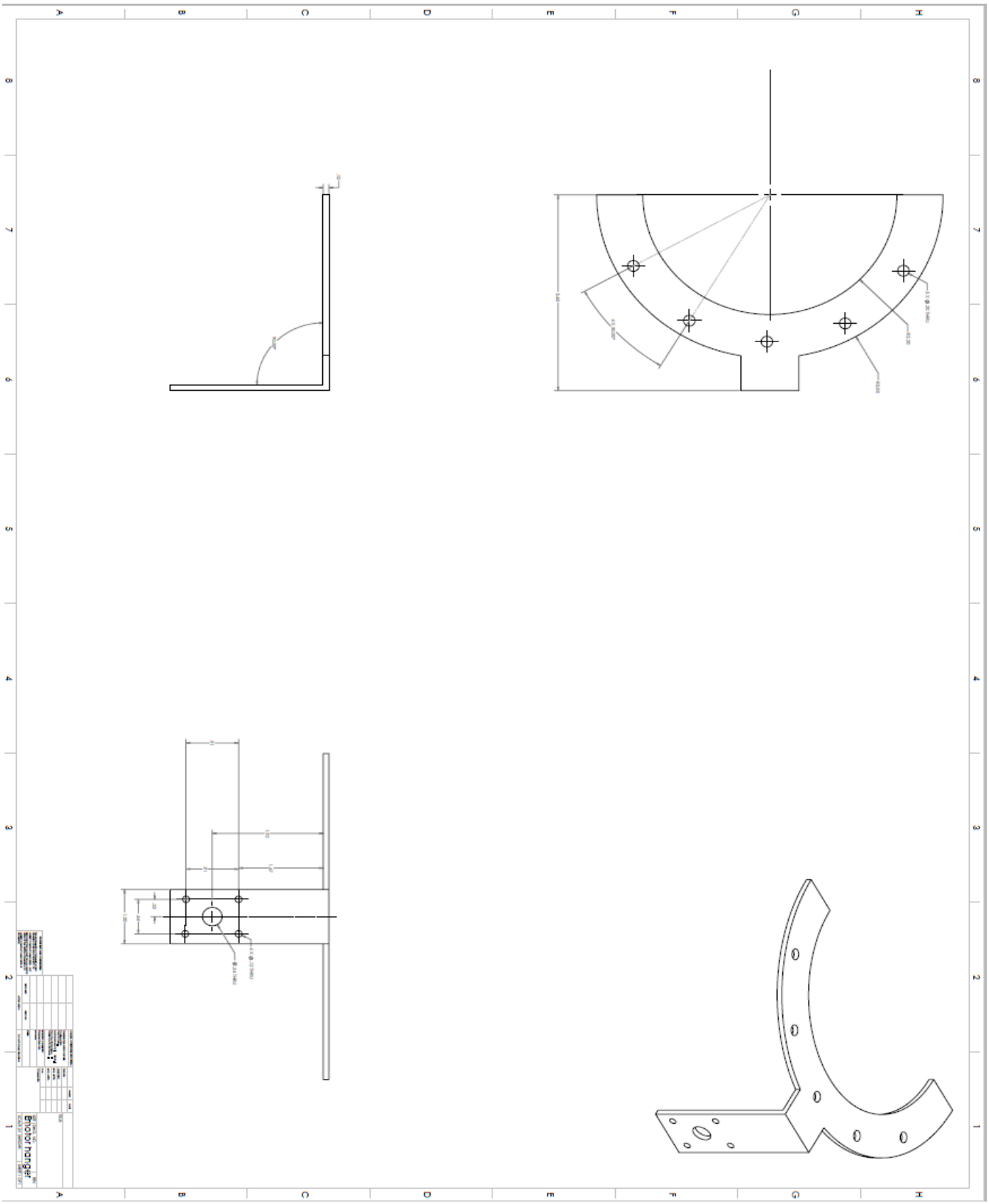
Blades



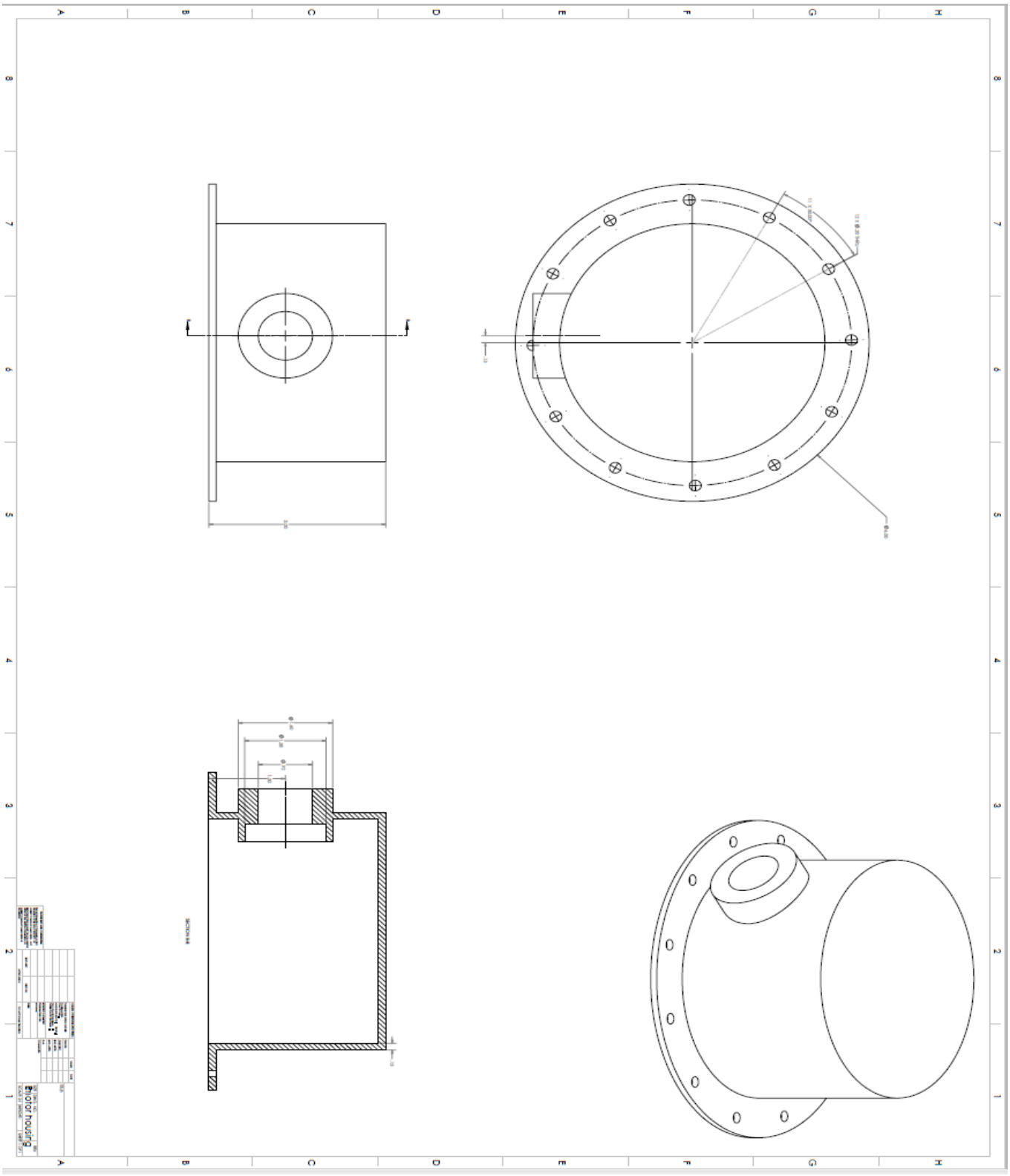
Motor Connector



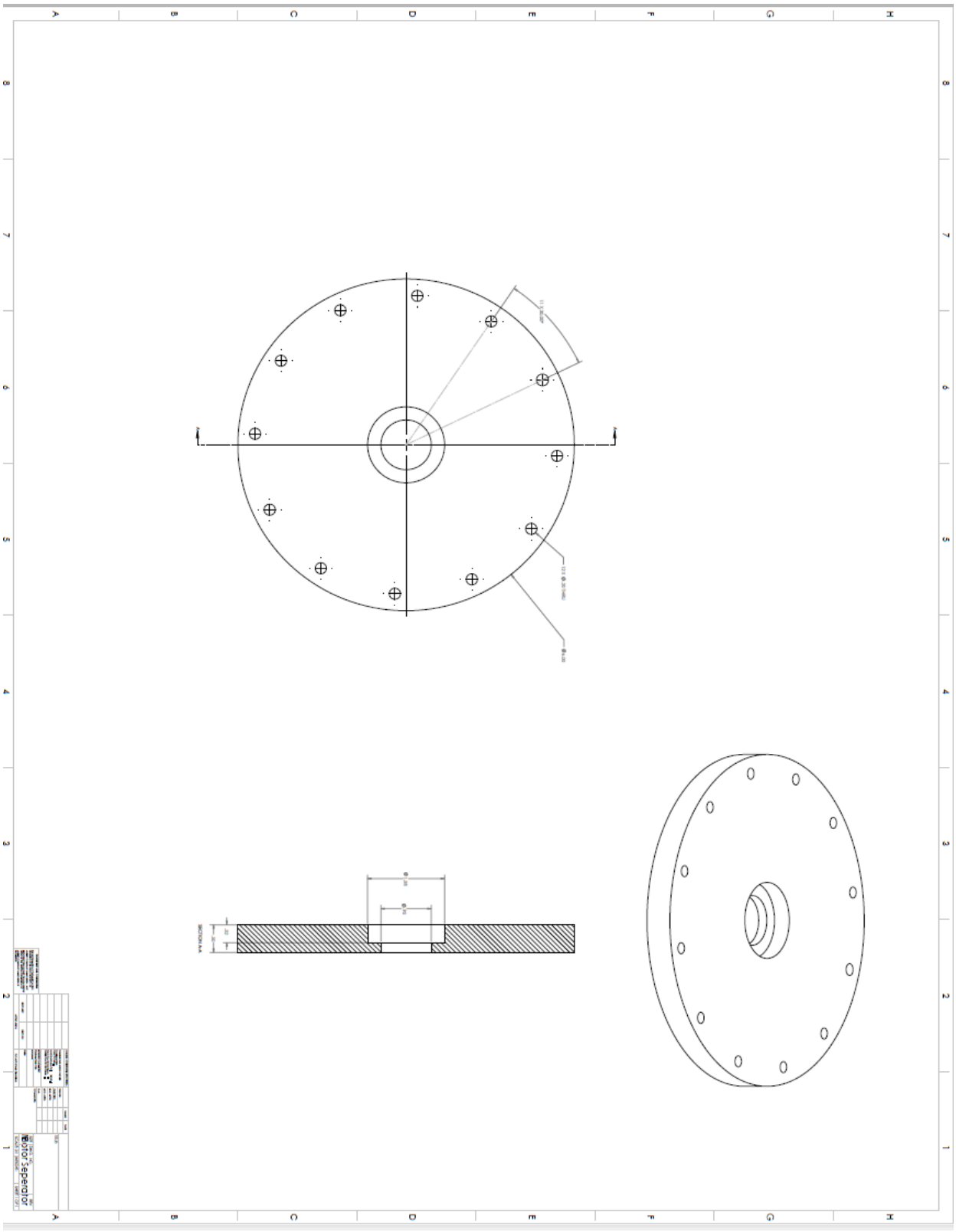
Motor Hanger



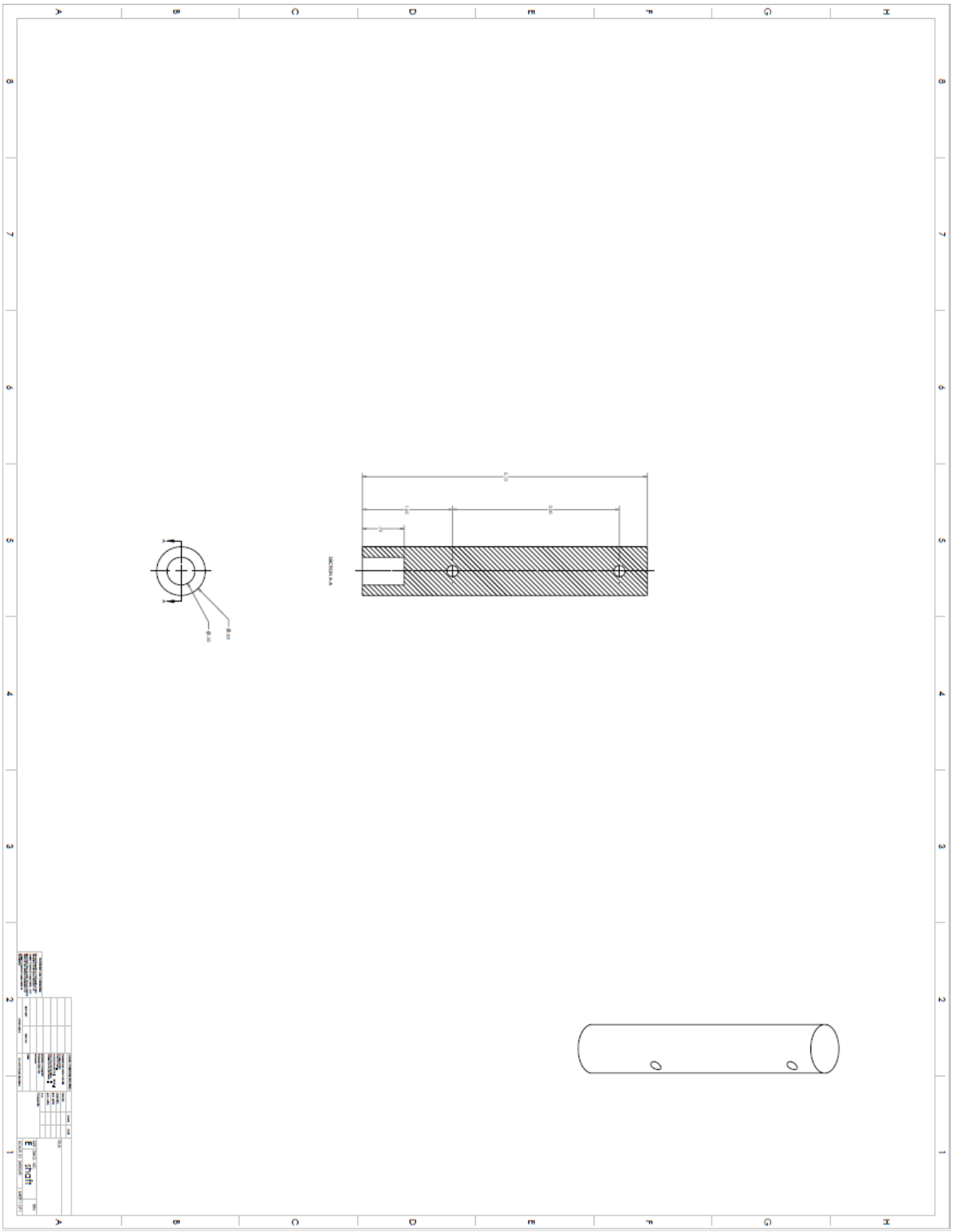
Motor Housing



Motor Separator

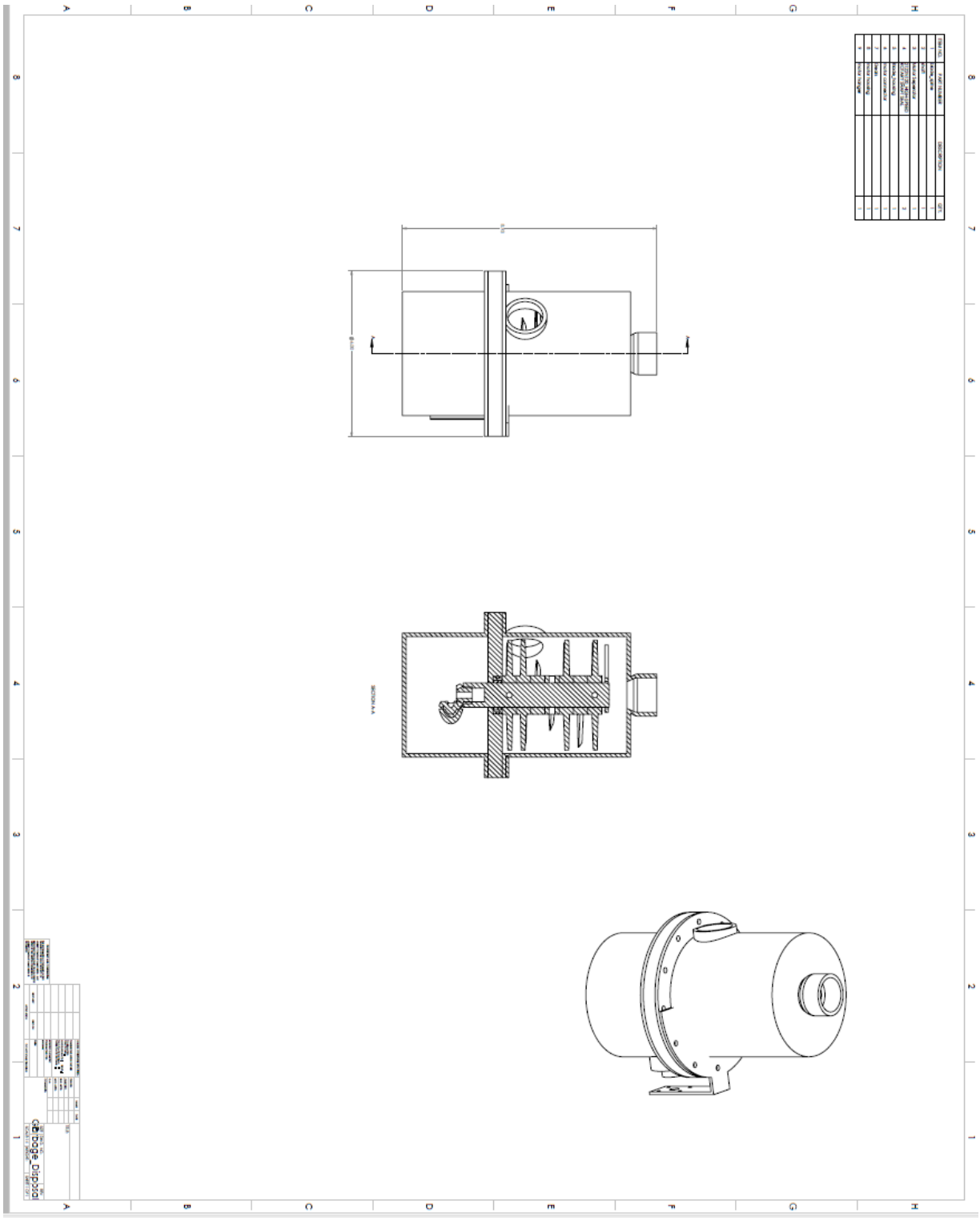


Shaft



Appendix B

Assembly Drawing



Exploded Drawing: