Retractable

Multi-Element Drop

Stage Machine Design Competition

USITT Midwest Regional Section

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Table of Contents

Design Specification

The purpose of the machine we have created is to accomplish a drop effect of objects such as flower petals, snow, confetti, ping-pong balls, etc. falling onto the stage. The swapping of face plates allows the user to make use of different materials for the effect. The effect that led to this machine design is for a production of Much Ado About Nothing. During the wedding scene of the production there needs to be a "rainfall" of flower petals on and around the two lovers. Given the light scoring of the scene, making the machine relatively silent is key. Our machine is operated offstage and is made to be user- friendly. Our machine consists of a frame that can secure to a 1-½" baton, and within this frame there are two cable retractors with cables running to a bucket (hereafter referred to as "the bladder"), and a motor that is used to revolve an agitator that is attached to its shaft. The motor used is a 90V DC motor that is geared down to 7RPM, thus producing 50inlbs of torque. The bladder is made from a 5-gallon bucket in which we used a hole saw to perforate the bottom of. The holes allow for the objects to fall through and down to the stage as they are agitated. The body and agitator of our machine can stay in position as it is reloaded, and the bladder is lowered to the stage. This is accomplished with the incorporation of two cable retractors in which hold our bladder in the air. Our bladder sleeves up into the outer body of the device, and the bladder itself is lowered to stage level manually by grabbing an eye bolt with a hook on the end of a pole. Ultimately, our machine can accomplish various effects, is easy to operate, simple and quick to reload. This machine can be re-used in various spaces and situations due to it being rather compact and versatile in its design.

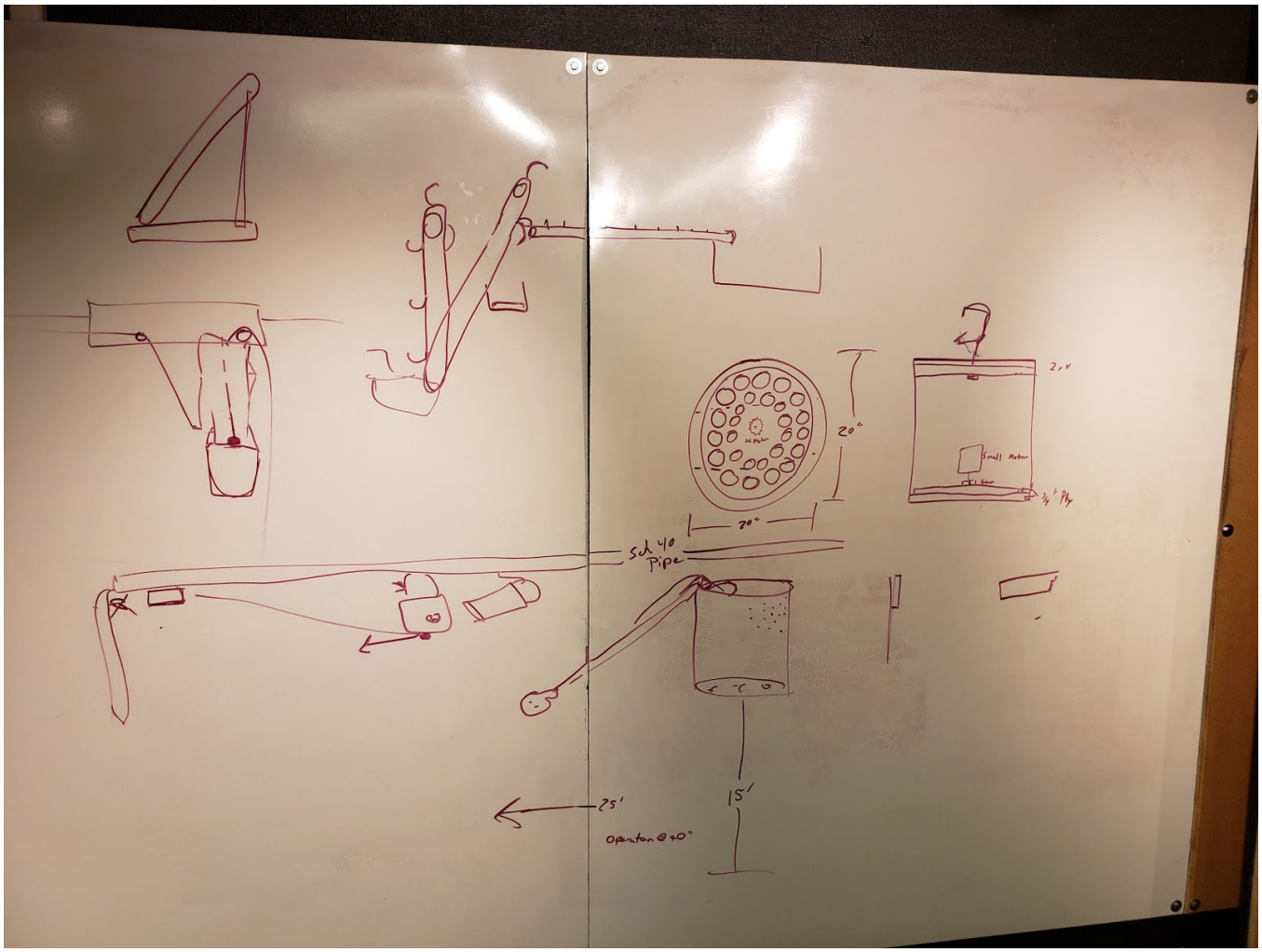
Concept Designs

During our initial conversations as we approached this design, the obvious challenge was how to refill the drop. Figure 1 (Page 3) shows our first meeting where we brainstormed different ways to refill the drop. Along top of the white board at center we sketched an idea of a conveyor belt delivery system. Our thought for this was to load a bucket on a vertical conveyor, have it deposit into a horizontal conveyor belt, which would drop it into our drop mechanism. We realized that given the constraints of the challenge, as well as the allotted space, a conveyor belt would not fall within the guidelines. This method would also be more expensive and technologically advanced than necessary.

Another design that we thought of to refill the bladder was using a bucket that travelled on a track that raised and lowered via a pulley system. A rope would be pulled to tip the bucket when it was positioned over the bladder, emptying its contents into the bladder of the machine. This can be seen in Figure 1, on the left and center of the board. We decided against this method out as we believed challenge the traveler track would take up too much space and the ropes used to control this system may have proved to be difficult to store.

Concept Designs

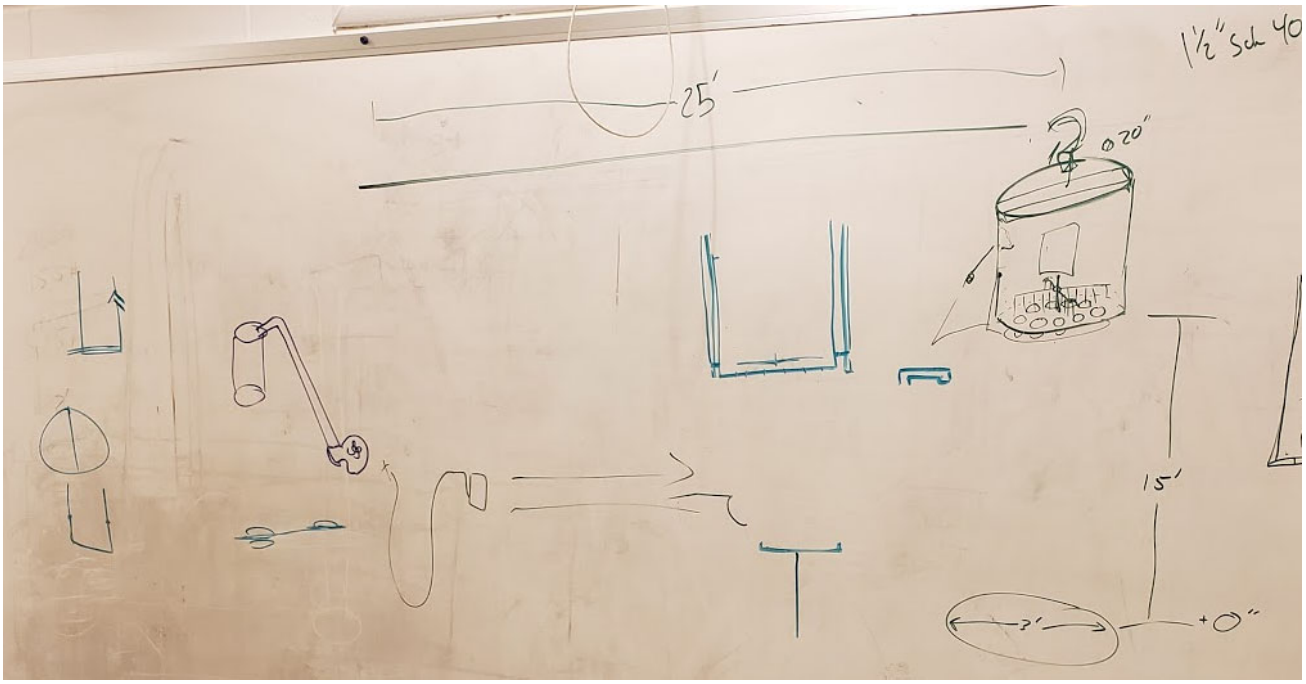
Figure 1:



Concept Designs

The third idea that we came up with was to use a blower motor to blow the petals up through a tube to drop bucket. Our sketches for this idea can be seen in Figure 1 bottom center and in Figure 2 on the left side of the board. We entertained this idea more than the ideas prior, but there were a few factors that forced us to stop considering this option. The first and most prominent issue was that blowing the petals up some sort of tube is easier said than done, as petals are can be quite temperamental. The second issue that we foresaw was that the air would likely blow our petals directly out of the bladder. We considered poking holes on the sides of the bucket and putting a screen on the top to help contain the petals, but we would also have to come up with a way to close the bottom of the bucket to prevent the petals from being blown out while loading. Ultimately the functionality of seating the tube from the end of the blower motor to the drop bucket in a safe and secure manor did not seem feasible. These concerns led us to scrap this idea and continue brainstorming.

Figure 2:



Final Concept Design

Our final concept design is the one we decided to move forward with and construct was a simple retractable bucket/ bladder with a motorized agitator. This method can be found in figures 3-5. The idea behind this is that there is an interior bucket or bladder that can be lowered via retractable cables. The bladder is lowered by an operator that grabs an eye bolt on the bottom with a hook and brings it to stage level. The bucket is then loaded and slowly let out, the bucket seats inside of a tube. This tube houses the agitator and connects to the steel frame. The steel frame houses the motor and cable retractors and has two C-clamps to connect to the batten. The agitator rotates and moves the petals around the bucket releasing the petals, or whichever object needs to be dropped from the machine, out the bottom of the bucket with pre-drilled holes. The bucket will have additional inserts with different sized holes to allow various materials to be used with this machine. We concluded that this was the best method to incorporate all the different elements of the challenge.

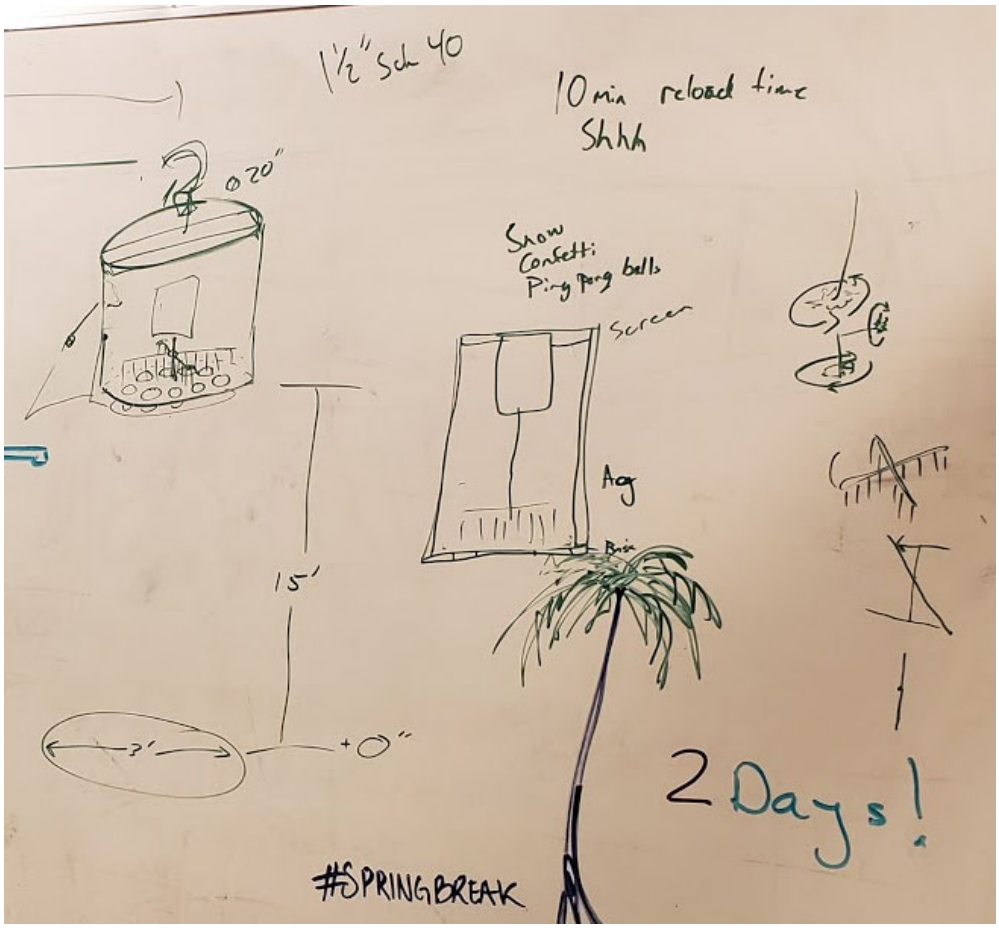
Once we decided on this idea we began to think about the practicality of the retractors, as well as how the cables interact with the bucket, the agitator, and the motor. Figure 3 showcases details regarding our thought process. The cable retractors give us the ability for an operator to reach the bucket with a pole, then pull it down to working height, refill it, and guide it back up to the tube housing. We decided upon having the bucket sit on a base that extends out past it and running the cables down to the base. This pulls the cable out from inside the bucket, therefore avoiding interference with the agitator. The agitator is controlled by a Dayton 90 Volt DC Gearmotor that has been geared down to 7 RPM. This gives us the most torque while still moving at a decent speed. We are using a Dayton DC Speed controller to convert the power from 115V AC to 90V DC, as well as to control the speed. Due to the motor being geared down so much we found the speed had to be set at 100% achieve the desired rate for our effect. This speed controller will serve as the operator station, it will be set up on a stand offstage for ease of operation. This design only requires a single NEMA ML-3 cable to run from the operating station, up to the batten, and over to the motor.

The agitator is spun by the motor by connecting it to the shaft of the motor by using a coupler secured with a set screw. However, holding the entire agitator up by a set screw on the motor shaft was a safety concern. To combat this, we built in a safety to the machine. The safety is a ring around the shaft of the agitator that is resting on a piece of 1x4 pine with a UHMW ring in between. This

Final Concept Design

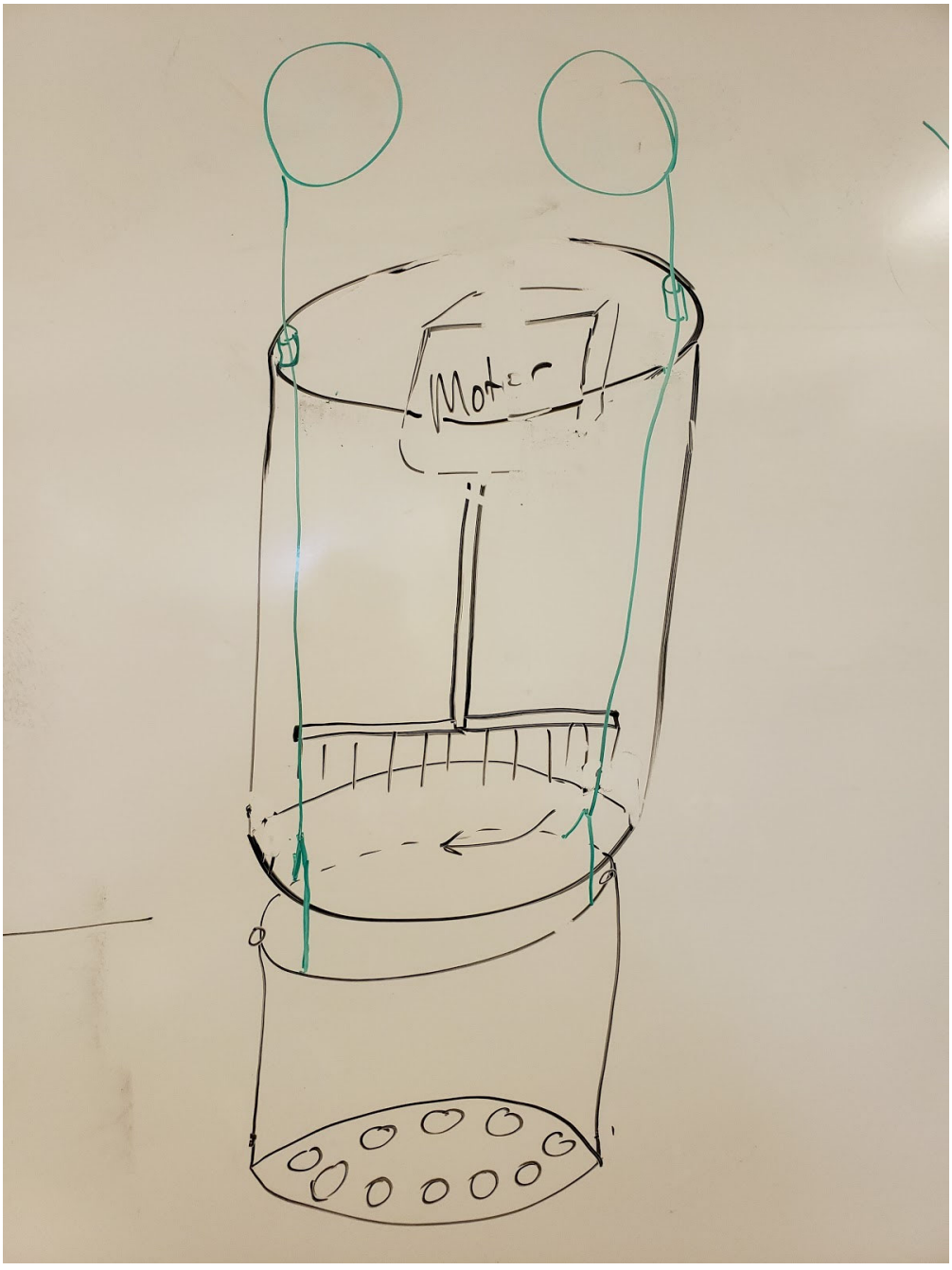
allows the agitators weight to sit on the pine, while the motor just controls the rotation and speed of the agitator (See Figure 4). Our original design called for the agitator “blades” to sit near the bottom of the bucket. This idea raised concerns about its ability to move the petals around, and if it would only compress and bunch the petals as opposed to allow them to drop from the bladder. Our follow up idea was to raise the agitator blades up higher and have “fingers” extend down into the bucket. The thought behind this is that the fingers are removable so that you can switch them out depending on the different types of objects you are using with the machine. With this we still wanted some downward force on the petals; we are prototyping the addition of a strip of rubber to hang off the lauan “fingers”. This would potentially apply some downward force and push the petals through the holes.

Figure 3:



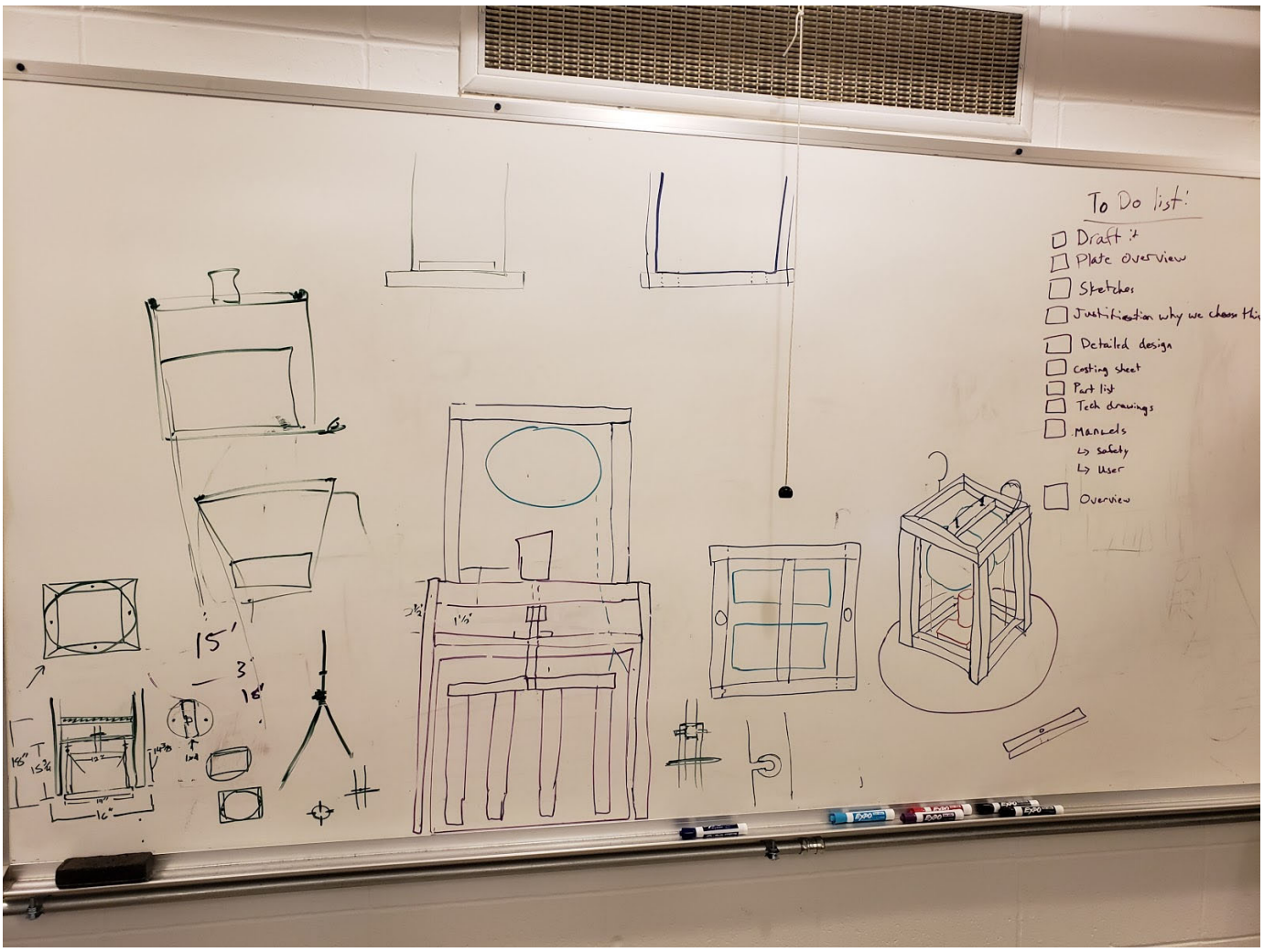
Final Concept Design

Figure 4:



Final Concept Design

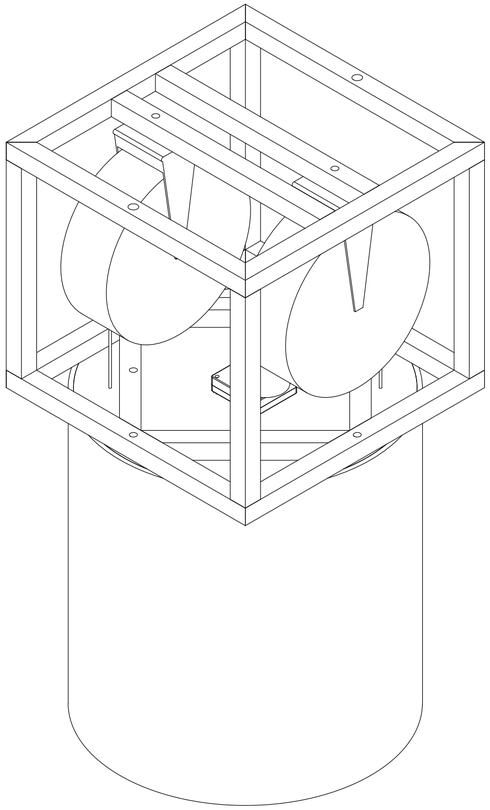
Figure 5:



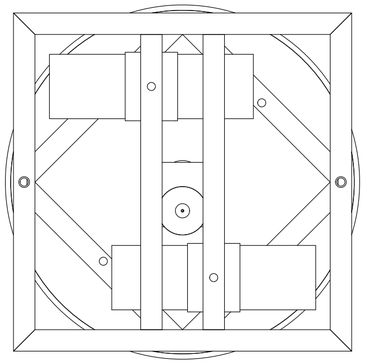
Detailed Machine Design

Parts list and Cost Estimate:

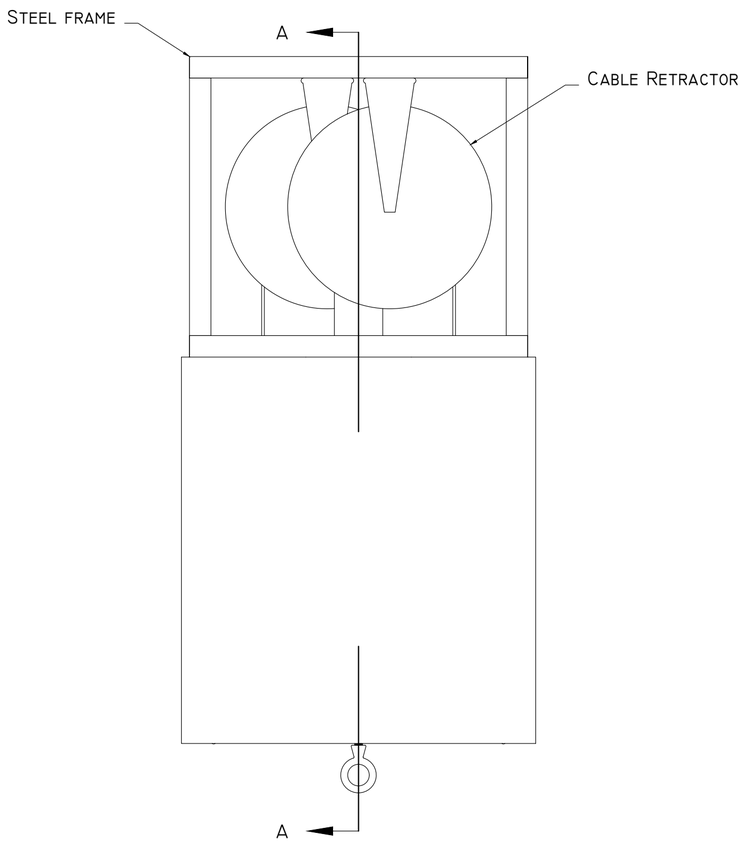
Part	Quantity	Cost	Purpose
90 V DC Motor	1	$205.00	To turn agitator
Dayton DC Speed Control	1	$180.00	Model # 4Z829B - 115AC convert to 90 DC
Cable Retractors	2	$58.99	Retract bladder
1x1x16ga Sq steel tube	1	$19.88	For frame and agitator
½"x½"x⅛" Sq steel tube	1	$13.84	For agitator shaft
16" sonotube	1	$15.12	For Exterior tube
C-Clamp	2	$18.90	To attach to batten
¼" Luan	1	$12.01	For Agitator blades
¾" Plywood	1	$14.23	For Base of Bucket and top of Sonotube
1x4 Pine	1'	$1.07 / ft.	To hold the Agitator
⅛" Aircraft Cable	40'	$.23 / ft.	For the bucket retractors
⅛" Nico Sleeve	2	$0.26	For the bucket retractors
⅛" Nico Stop	2	$0.28	For the bucket retractors
2-¼" ¼"x20 Bolt	14	$1.08	To bolt steel frame to Plywood
1-¼" ¼"x20 Bolt	2	$0.25	For cable retractors
¼" Nylock Nut	16	$0.79	
¼" Washers	32	$8.25 (100 ct)	
1"x1" UHMW plate ¼" thick	1	$10.24 / sqft	Friction glide for agitator
⅜" Eye-Bolt	1	$3.89	For hook
Retractable Polearm	1	$33.98	For hook mechanism
Total Cost:		$606.10	*Based off purchasing everything needed without use of any stock items*



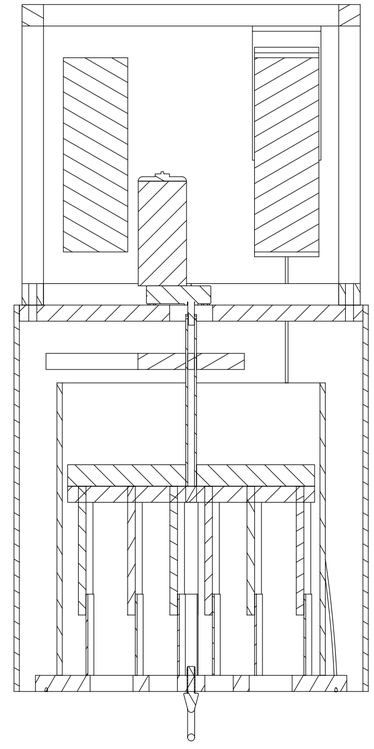
Composite Top Isometric view



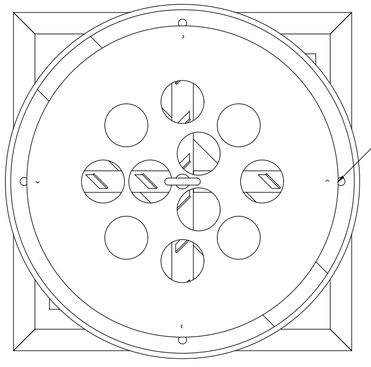
Top View



Front View



SECTION A-A
SCALE 1:5



Bottom View

Drop created to drop multiple elements, ranging in size, from a secured location above intended area. Bladder of drop can be brought in by an operator on the floor with a hooked pole and reloaded when needed.

Composite Plate

Scale: As Noted
Revision Date: 4/12/2019
Drafted By: BR

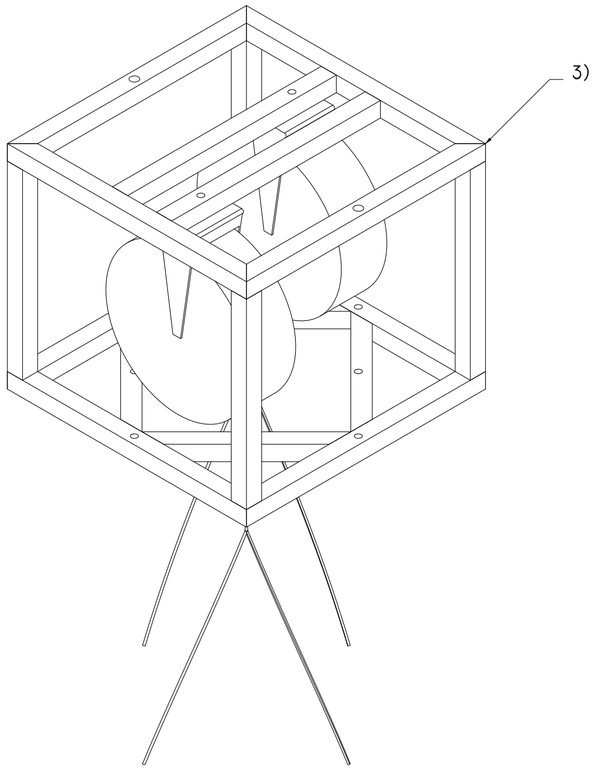
Retractable Multi-Element Drop

N/A

Director: N/A
Designer: N/A
Stage Manager: N/A
Technical Director: Bobby Reynolds

01

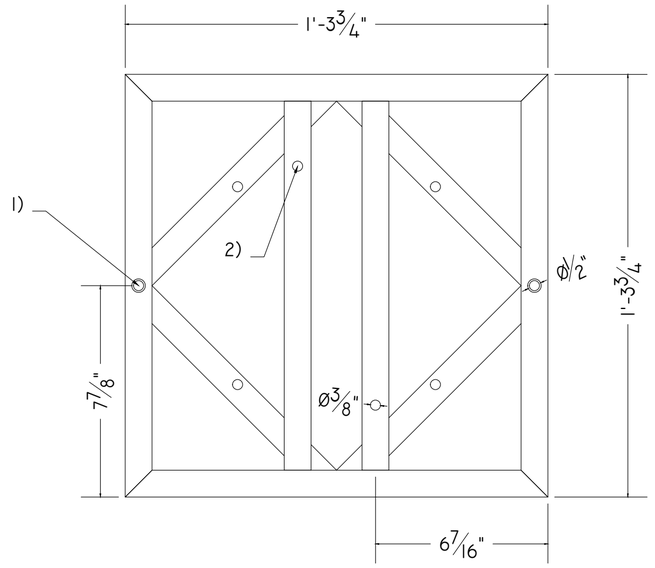
1 Drop Composite
SCALE: 1:5



Frame Top Isometric view

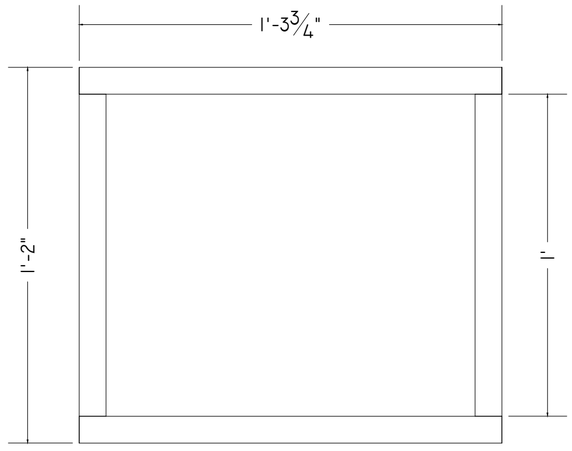
Side View

1 Steel Frame with Retractor
SCALE: 3"=1'

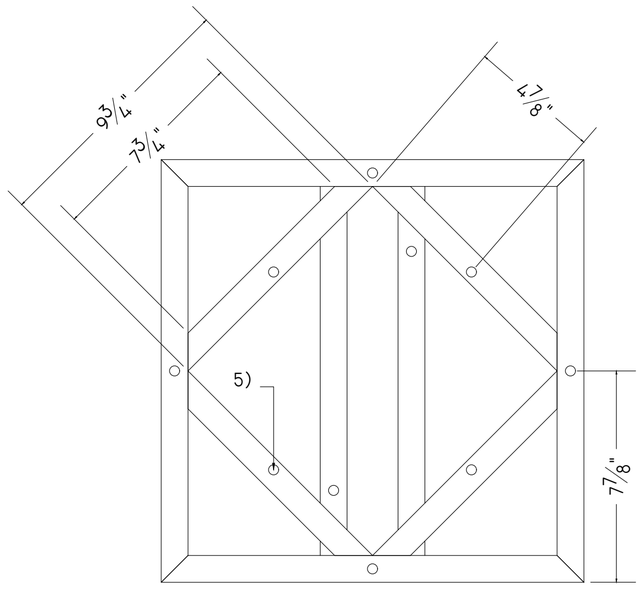


Top View

1) Holes for C-clamps for batten attachment
2) Holes for Retractor bolts
3) Frame made of 1x1 14 GA Box tube
4) Retractor holds 1/8" aircraft cable
5) Holes for 1/4" hardware to top of exterior drum



Front View



Bottom View

2 Steel Frame without Retractor
SCALE: 3"=1'

Steel Frame

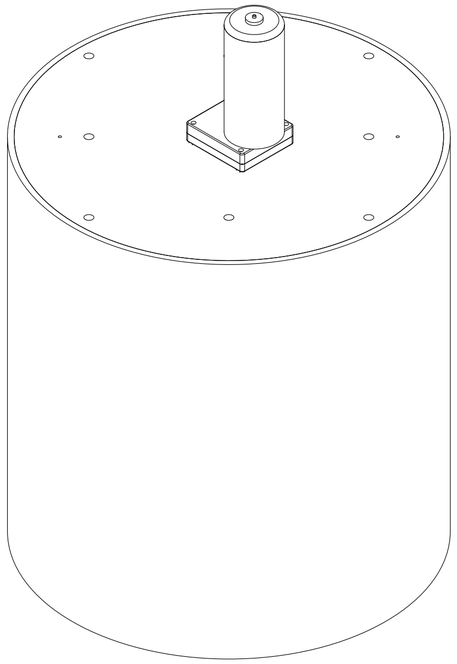
Scale: As Noted
Revision Date: 4/12/2019
Drafted By: BR

Retractable Multi-Element Drop

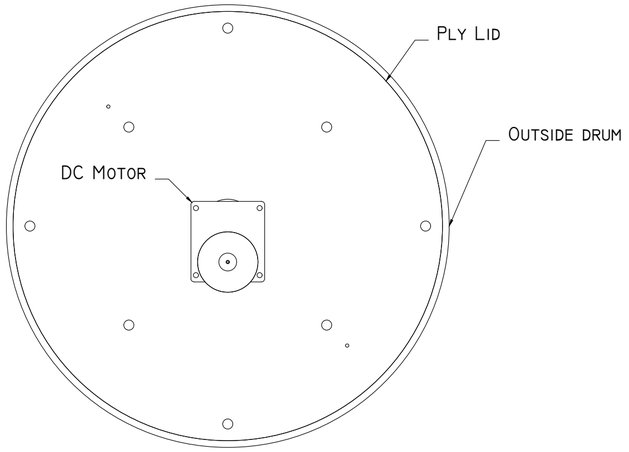
N/A

Director: N/A
Designer: N/A
Stage Manager: N/A
Technical Director: Bobby Reynolds

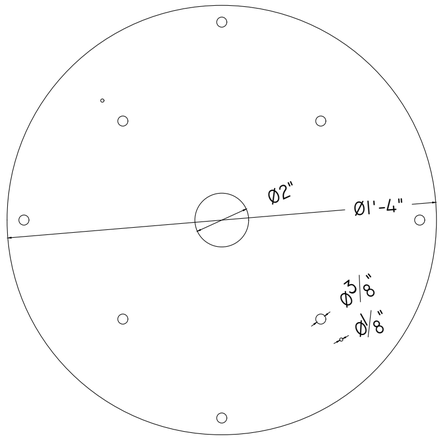
02



Isometric View

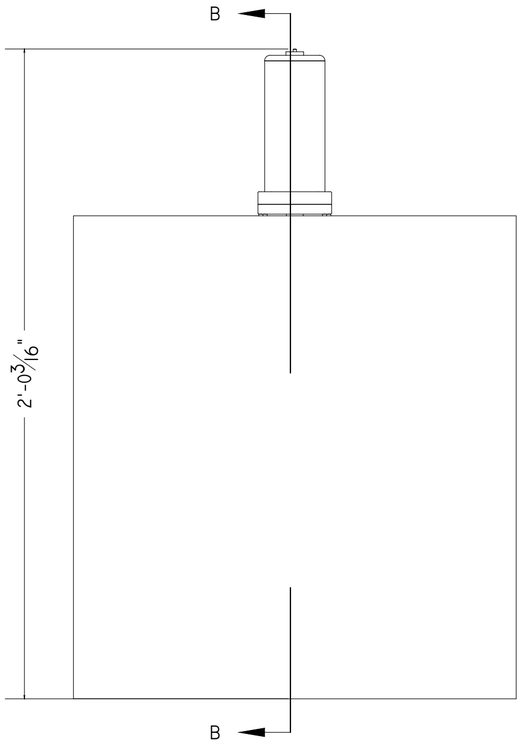


Top View

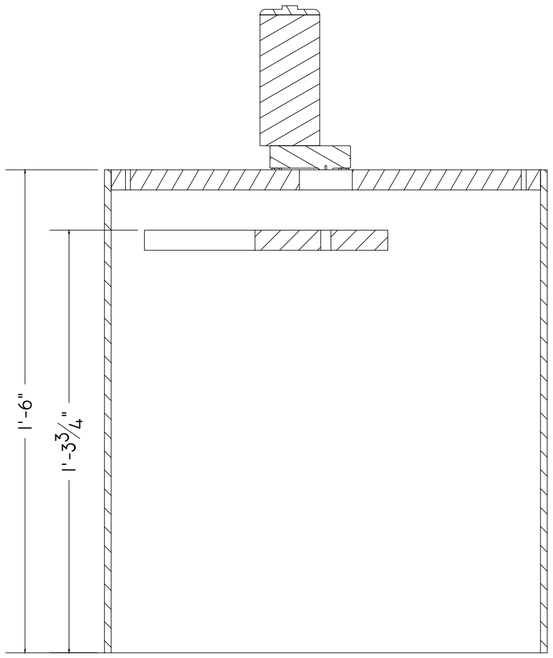


Plywood Hole Pattern

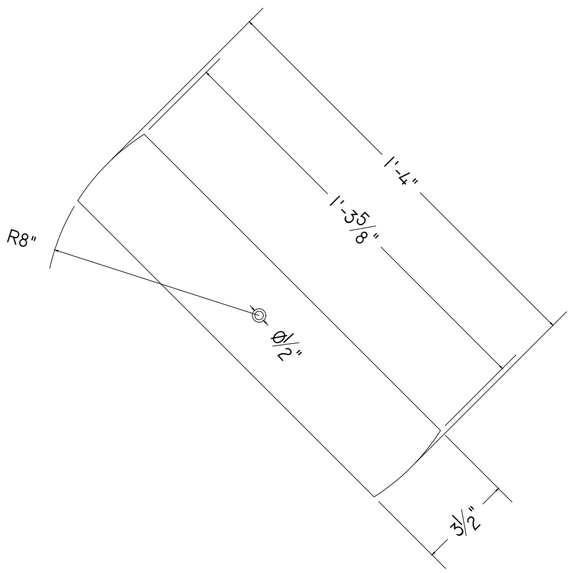
1) 16" Ø Sonotube for shell adhered to $\frac{3}{4}$" Plate with adhesive and staples
2) DC Motor mounted to top of lid with machine bolts
3) Shaft guide adhered to sonotube with adhesive and staples
4) Hole Pattern cut on CNC router or can be hand drilled through steel frame holes.



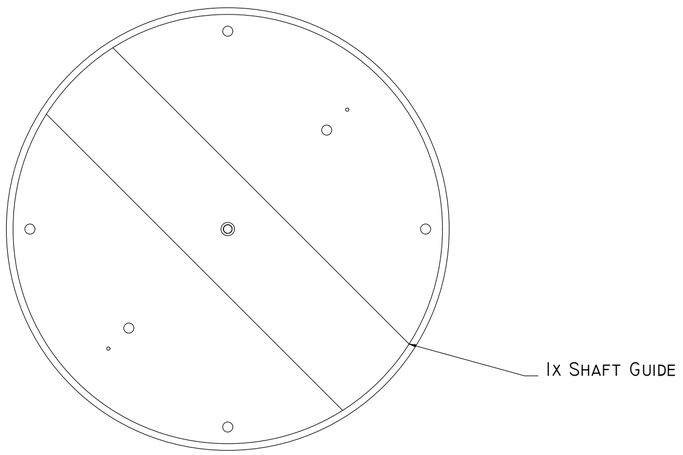
Front View



SECTION B-B
SCALE 1:4



Shaft Guide Bottom View



Bottom View

1 Exterior Drum
SCALE: 3"=1'

Exterior Drum Assembly

Scale: As Noted
Revision Date: 4/12/2019
Drafted By: BR

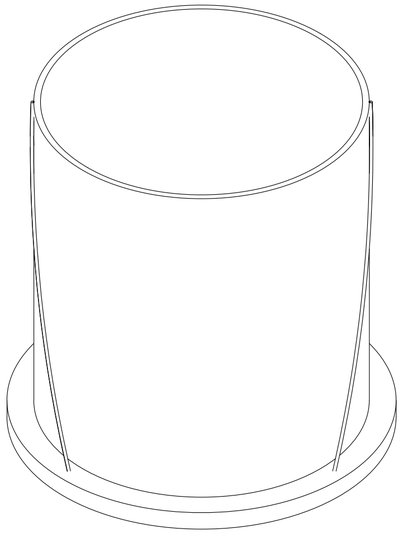
Retractable Multi-Element Drop

N/A

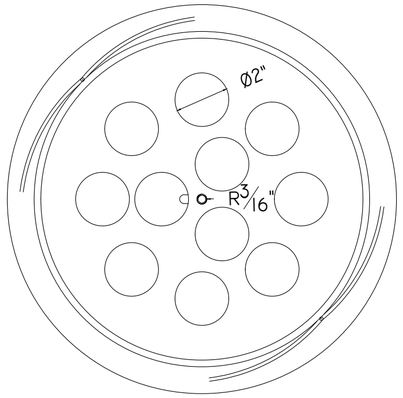
Director: N/A
Designer: N/A
Stage Manager: N/A
Technical Director: Bobby Reynolds

03

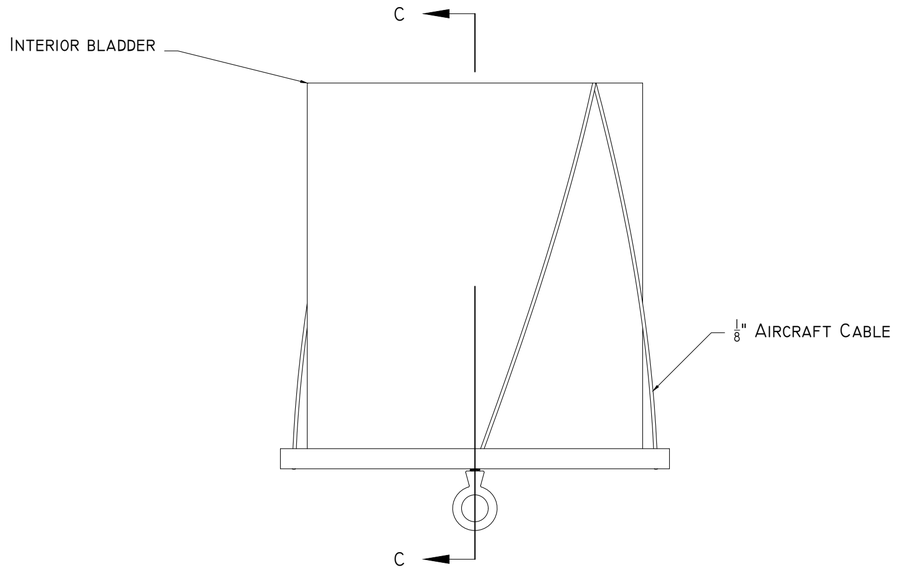
1) Basket held up by $\frac{1}{8}$" aircraft cable with Nicco stops on bottom
2) Eyebolt installed for hooking from deck
3) Base plate made of $\frac{3}{4}$" Plywood
4) Interior bladder made from 1' Sonotube
5) Hold pattern made on CNC or can be hand drilled



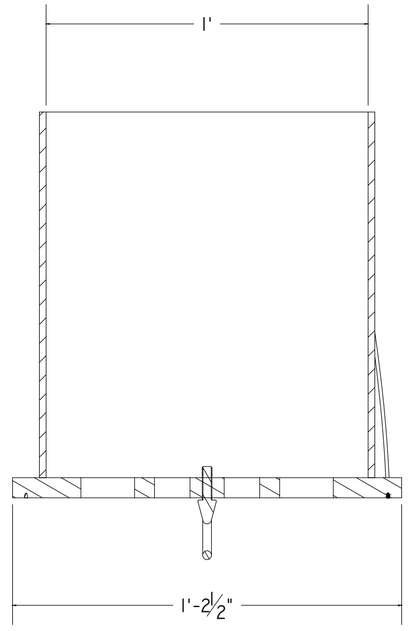
Isometric View



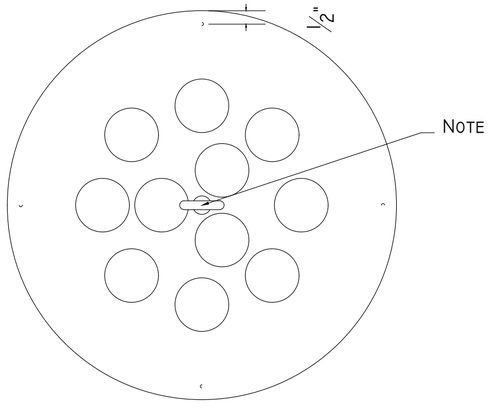
Top View



Top View



SECTION C-C
SCALE 1:4



Top View

1 Bladder Assembly
SCALE: 3"=1'

Interior Drum Assembly

Scale: As Noted
Revision Date: 4/12/2019
Drafted By: BR

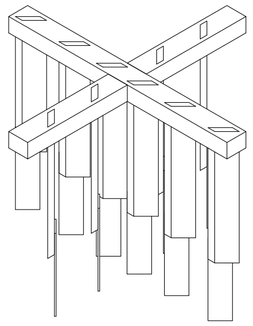
Retractable Multi-Element Drop

N/A

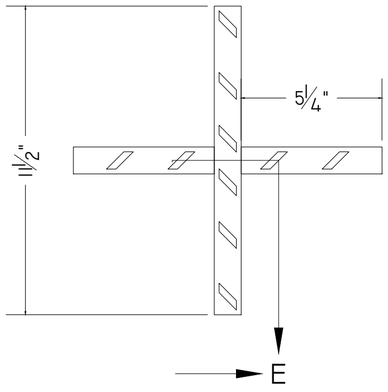
Director: N/A
Designer: N/A
Stage Manager: N/A
Technical Director: Bobby Reynolds

04

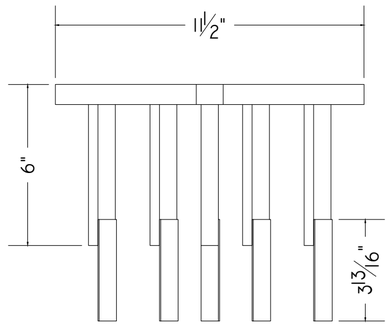
1) Agitator extension made of $\frac{1}{4}$" ply slotting into 1x1" lumber with rubber strips stapled onto ends
2) Agitator frame is made of 1x1 14 ga box steel
3) Shaft is made of $\frac{1}{2}$" pipe at $\frac{1}{8}$"GA
4) Pin is to be inserted into shaft of motor through agitator shaft
5) Agitator extension pieces will be bolted to frame
6) Guide washer welded to shaft for safety



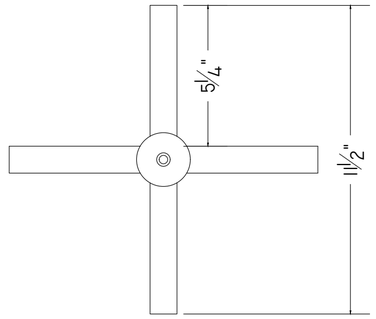
Isometric View



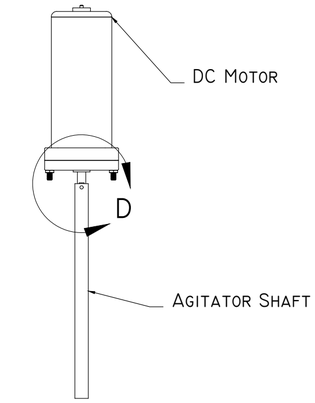
Top View



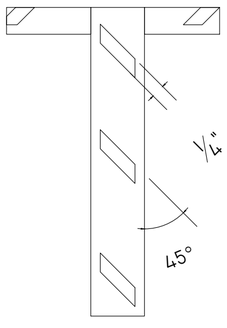
Front View



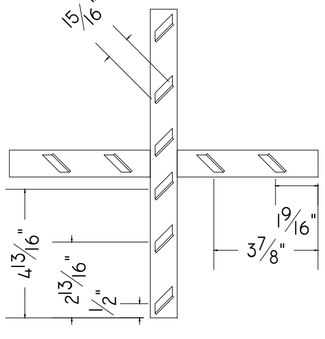
Top View



Front View

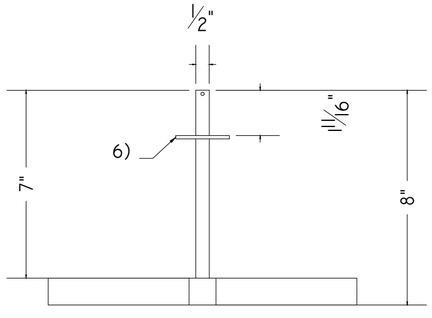


DETAIL E
SCALE 1:2



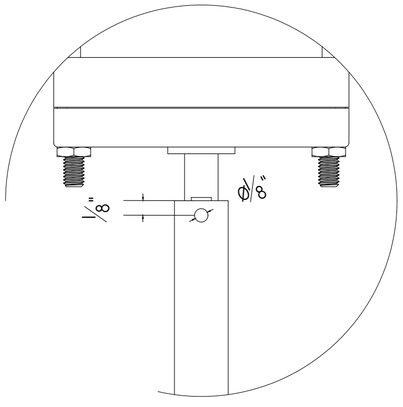
Bottom View

1 Agitator Extension
SCALE: 3"=1'



Front View

2 Agitator Frame
SCALE: 3"=1'



DETAIL D
SCALE 1:1

3 Motor and Shaft Conection
SCALE: 3"=1'

Agitator Assembly

Scale: As Noted
Revision Date: 4/12/2019
Drafted By: BR

Retractable Multi-Element Drop

N/A

Director: N/A
Designer: N/A
Stage Manager: N/A
Technical Director: Bobby Reynolds

05

User Manual and Safety Protocols

Safety Protocols:

1. Whenever flying batten observe safe counterweight rigging practices
2. When attaching rig to batten make sure bolts are tightened and a safety cable is properly installed
3. During setup and reloading keep the motor unplugged
4. Never put hand inside bladder while the motor is running
5. While loading have someone keep a firm hold on the bladder so it does not run back into the retractors
6. Never allow the cable retractors to retract at full speed, maintain control with the hook mechanism
7. Announce all test and runs of machine clearly and at ample volume while not in a performance

Part 1- Installation:

1. Fly in a batten to a working height
2. Attach drop mechanism to the batten using the C-Clamps at the top of the frame. Ensure the clamps are tightened and secured to batten
3. Attach safety cable to the mechanism, ran around a piece of the 1x1 steel frame
4. Run 120V power AC power to the control station from an outlet
5. Run power cable from control station to the motor in the drop mechanism and tie cable to batten
6. Test motor and agitator arm to ensure they are functioning properly
7. If using a counterweight rigging system weight batten appropriately before attempting to fly
8. Fly batten out to trim height

User Manual and Safety Protocols

Part 2- Loading Bladder:

1. Extend hook mechanism to appropriate length to grab the eye bolt that is secured to the bottom of the bladder
2. Slowly pull the bladder down to a safe working height
3. Have one person firmly hold the bladder in place
4. While bladder is being held by one person, the hook operator will fill it with material of choice for the production
5. Once the bladder is filled re-attach the hook and slowly let the cable retractors fly out bladder while maintaining attachment to eye bolt
6. Make sure that the bladder seats firmly in housing
7. Detach and retract “hook on a stick”
8. Run motor for 5 seconds to seat agitator correctly and ensure sure things are dropping.
9. Clean up any of the things that were dropped while testing

Part 3- Operation:

1. The speed of the motor is set on the Speed Controller, this setting should be preset to 100%
2. Operator Sets the direction of the controller to “FWD” when given the standby from Stage Management
3. When the cue is given the operator will flip the lower switch on the controller from “STOP” to “Run”
4. To turn off the motor, the operator switches the lower switch from “RUN” to “STOP”
5. Once the motor has stopped the operator should switch the upper toggle switch from “FWD” to the neutral setting in the middle. This acts as a safety, so that the motor cannot accidentally run with the flip of one switch