

ATV Mountable Tree Planting Station

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SIGNATURES

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PREFACE AND ACKNOWLEDGMENTS

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ABSTRACT

This project consists of the design, construction, and evaluation of an ATV mountable tree planting station. The project was carried out with the goal of designing and fabricating a piece of machinery that could be easily towed by an ATV and would reduce the amount labor involved with planting tree saplings. The catalyst for this project was the need to replant a 40 acre piece of property in Bozeman, MT that has recently been logged.

The design contains a gasoline driven auger with a three inch earth auger bit for making holes, a water tank for applying water and fertilizer to new saplings, and a container for holding bulk amounts of tree saplings. The auger is counterbalanced on a pivot arm so it can be easily operated by a single person. The machine was designed and fabricated to be used specifically with a Yamaha Grizzly 700 ATV.

The effectiveness of the ATV mountable tree planting station was evaluated based on the ease of operation and the success of the auger digging a hole large enough to insert a tree sapling. The machine was tested in several different soil types to test effectiveness in varying terrain. The machine was also loaded and towed to ensure it could perform in the terrain it was designed to be used in.

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INTRODUCTION

Background

Logging is a large industry and one that will not soon disappear. Trees are cut and removed for numerous uses and once a piece of land has been logged it can take years for the land to reforest through natural means. Tree saplings can be planted in order to speed up the process of reforestation. Planting hundreds of saplings by hand takes a large amount of manual labor.

Justification

Recently, forty acres of land in Bozeman, MT owned by Robert Rogers has been almost completely logged due to a pine bark beetle infestation and necessary forest fire precautions. Roughly two thousand pine trees were removed from the area and it is now almost barren. The natural repopulation of pine trees is a slow process and takes years for saplings to begin sprouting. If pine tree saplings could be transplanted, the amount of time needed to reforest the area would be significantly reduced. The amount of time for tree saplings to grow is large, but eliminating the time it would take for the trees to germinate from natural left over seeds would speed up the reforestation process significantly. Transplanting pine trees by hand is a labor intensive process. An aid that could reduce the amount of work needed to transplant pine trees would be ideal.

Objective

The goal of this project is to design an implement that can be towed by an ATV in semi-rough terrain and that significantly reduces the amount of manual labor involved with transplanting bulk amounts of tree saplings. The implement will be able to be operated by a single person and will carry a large quantity of tree saplings. The amount of manual labor and time needed to plant a bulk quantity of tree saplings will be reduced significantly as compared to transplanting the saplings by hand. The transplant aid will contain all the necessary features for a successful pine tree transplant. It will include a water tank, an auger, a storage area for a bulk amount of tree saplings, and hitch so that the implement may be towed by an ATV.

LITERATURE REVIEW

The agricultural industry has made significant advances within the area of crop transplanting. Currently on the market there are both mechanically driven transplanting implements and fully automated transplanting machines. These machines can be used to transplant a variety of crops and can either be implements that are towed behind a tractor, or self sufficient machines that are capable of moving themselves throughout a field. Other implements that are currently on the market within the agricultural industry are augers and soil coring devices. Augers can be driven by the PTO of a tractor, a hydraulic pump, or gasoline engines. Soil coring devices can be manually operated such as soil profile samplers, or they can be hydraulically driven.

Mechanical Transplanting Implements

Mechanical transplanting implements are most often towed behind a tractor and utilize machinery that is mechanically driven off of a gauge wheel that meters the crop into the soil at a set soil depth and plant spacing. This type of transplant aid is very common in the tomato and row crop industry. Mechanical transplanting aids can have multiple stations that will insert transplants into multiple crop rows in a single pass. These larger transplanting aids are often used for larger fields and when larger tractors can be used to pull them.

The mechanical transplant aid utilizes a set diameter gauge wheel that rolls in a straight line parallel to the direction of the tractor. The gauge wheel is connected to a drive that forces a plunger into the dirt at a set depth. As the tractor pulls the transplant aid, a plow at the front of the aid is used to break up the dirt, making it easier for the crop to be inserted into the soil. The plunger is the mechanism that physically moves the crop and inserts it into the soil. Once the crop has been inserted into the soil by the plunger, compaction wheels force the plowed dirt back into place so that a good connection between the crop and surrounding soil can be made. The compaction wheels and gauge wheel can be seen below in Figure 1. This process happens at a continuous rate that is based off of the diameter of the gauge wheel and any gear ratios that may occur between the gauge wheel and plunging device.

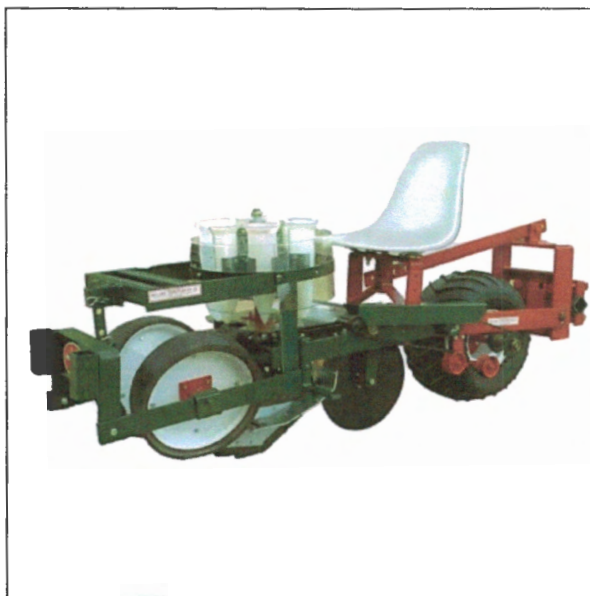


Figure 1. Rotary One Transplanter (Holland, 2014).

Mechanical transplant aids still require human labor and human interface in order for them to function. The seedlings must be inserted into the plunging chute by an operator. The mechanical design of the chutes varies between transplant aids as can be seen with the Rotary One Transplanter by Holland above and the 580 Bed Planter Unit by Mechanical Transplanter that can be seen below. Once the transplants are in the chutes, the mechanical actions of the implement will plant the seedlings at the correct depth and spacing. Mechanical transplanting implements help significantly to reduce the amount of manual labor associated with the transplanting of crops. While the device still requires human labor in order to function, mechanical type transplanting implements are much cheaper than the automated machines and greatly reduce labor and man hours when compared to planting crops by hand.

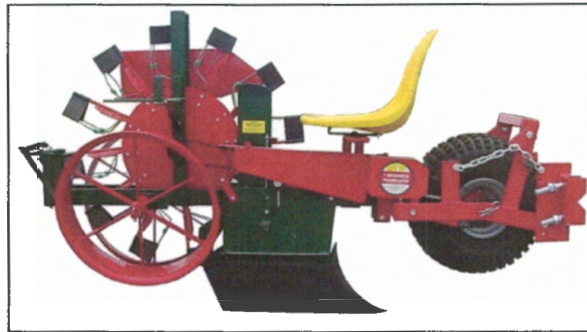


Figure 2. 580 Bed Planter Unit (Mechanical Transplanter, 2014).

Automated Transplanting Machines

There are currently transplant systems on the market that are fully automated and require little or no manual labor. Some of the more sophisticated systems in the industry are run off of micro-controllers and utilize very sophisticated technology. Automated transplanters function much like mechanical transplanting implements. They utilize a plow to break up the dirt, a plunger to set the crop in the soil, and compaction wheels to force the plowed dirt back around the newly planted crop. The main difference between automated transplanters and mechanical transplant aids is that the automated machines do not require an operator to move the seedlings from a tray to the plunging chute. Automated transplanters utilize micro-controllers, and sensors to run pieces of equipment that pick a seedling from a tray and insert it into the plunging chute.

A machine by Transplant Systems, plants up to 18 rows of a crop in a single pass. The system is state of the art and utilizes no manual labor for transplanting except for an operator driving the tractor. The speed and volume in which crops can be transplanted using this machine is incredible. Much like the mechanical transplant aids, this system utilizes plungers and plows to position the plants at the correct spacing and depth. The main difference between the mechanical transplant aids talked about above and the machines produced by Transplant Systems is the automated moving of the plants from the trays to the plunger chutes. Many trays of seedlings are stored on board the transplanting machine which allows for large fields to be planted quickly and efficiently. As a tray is emptied of seedlings, a new tray is moved into position and the process of transplanting continues without any lag time between trays.



Figure 3. 4 Row Automatic Planter (Transplant Systems, 2014).

Augers

Augers are used as a means to dig relatively large diameter, deep holes with a small amount of effort. Augers function by utilizing a large “drill bit” that is turned and lowered into the soil. As the bit is turned into the soil, soil cuttings are removed and a hole is formed. Once the correct depth has been reached the auger is removed and what remains is a hole with loose dirt around it. Augers are typically used within the agricultural industry to help with installing large fence posts that would otherwise require a large amount of manual labor to install. Depending on soil conditions and available power, various diameter auger bits can be used. However, the larger the bit, the more power will be required to turn it and remove the dirt. Tractor mountable augers make digging large holes much easier. Augers are heavy pieces of equipment and can be difficult to move around manually. When augers are mounted they become much more user friendly and can be used for a larger variety of tasks than a man-held auger.



Figure 4. Bobcat Auger (VHR Rental & Supply, 2014).

There are several ways that an auger can be powered. Augers can be powered by hydraulics run off of a pump, the PTO of a tractor, or a separate gasoline engine. Depending on the size of the auger bit, the correct speed for an auger to turn is between 60 RPM and 150 RPM. When using large auger bits, the smaller RPM side of the scale would be desirable. When using a smaller auger bit, faster RPM rates can be used.

Augers that are run off of hydraulic pumps have the possibility of offering much greater torques than augers run off of a standard PTO or small gasoline engine. With larger amounts of torque, larger bits can be used to make larger holes. Also, depending upon the hydraulic valving available on the tractor, the rotational speed of the auger can be adjusted through the use of flow control valves. Bobcat has a hydraulic auger attachment on the market for skid steers that operate with torques of up to 5272 ft-lbs. This auger utilizes the Bobcat skid steer hydraulic system to power the device. Large diameter auger bits can be used due to the large amount of torque that this system has available. Bits can range in size from six inches to forty eight inches and can dig as deep as seventy three inches (Bobcat, 2014).



Figure 5. Bobcat Skid Steer with Auger (Bobcat, 2014).

Augers can be mounted on the back of tractors utilizing a three point hitch and the tractor's PTO as a means of power. These auger systems use the hydraulics attached to the three point hitch as a means of raising and lowering the auger and use the PTO to turn the auger bit. These auger systems provide about 1813 ft-lbs of torque and have a smaller maximum diameter auger size that can be used (Danuser, 2014). A PTO run auger known as the "Model F8" by Danuser can only utilize auger bits with a diameter up to thirty inches. While this would still make an extremely large hole, it does not have the same capability as some hydraulically driven augers.



Figure 6. PTO Auger "Model F8" (Danuser, 2014).

Augers can also be hand held and take one or more people to operate the device. The man-operated augers consist of a gas engine driving an auger bit into the soil with an operator(s) holding it in place and upright. These machines take more manual labor than the tractor operated auger implements mentioned above. Though more manual labor is required, the augers significantly reduce the amount of work it would take to do the same job with only hand tools. The auger diameter that these machines are capable of using is smaller than the hydraulic and PTO augers are capable of using. Man-held augers such as the Ardisam Two Person Auger Powerhead are only capable of turning a ten inch diameter auger bit and have significantly less power than hydraulic and PTO augers. The amount of labor that goes into using a machine such as the Ardisam Auger Powerhead is dependent upon the soil conditions as well as the size of the hole that is being augured out.



Figure 7. Ardisam Two Person Briggs and Stratton-Powered Earth Auger Powerhead (Notherntool, 2014).

Soil Coring Technology

Another device used in the agriculture industry is soil coring machines. Soil coring technology utilizes a device that is forced into the soil and a small cylindrical sample of dirt is removed so that it can be tested, and it leaves behind a small hole in the field. Currently the company Precision Technologies offers an ATV mountable hydraulic coring sampler. The device can either be run off of hydraulics previously installed on an ATV or it can be purchased with a self contained hydraulic system with the soil sampling device. The sampler is capable of actuating and removing a soil sample in about two seconds. Once the sample has been removed from the ground, the dirt is forced out of the coring tube into a sample box and the process can begin again. Numerous samples can be taken in a matter of seconds and the device is easily transported through the use of an ATV. The device can actuate and remove samples from depths of six to twelve inches (Precision Technologies, 2014).



Figure 8. Wintex 1000 Hydraulic Soil Sampler (Precision technologies, 2014).

Another type of soil coring device is a soil probe that is manually pushed into the soil. This device utilizes human labor to insert and remove the probe from the ground. Once the device is pulled out of the ground, a small hole is left behind and a soil core sample resides within the probe tube. The holes left behind these types of probes are fairly small, around one inch in diameter. Depending on the length of the probe, different depths of sample can be achieved.

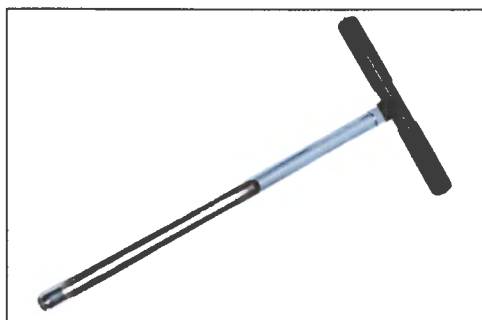


Figure 9. Soil Probe (AMS, 2014).

DESIGN PROCEDURE

ATV Constraints

The tree planting station will be mounted and towed by a Yamaha Grizzly 700 ATV. The Yamaha Grizzly 700 has a 686cc four stroke engine and is four wheel drive capable. The height of the hitch is approximately thirteen inches from the ground. The hitching mechanism is a metal tab with a hole for a pin connection between the ATV and machine as can be seen in Figure 10 below.



Figure 10. Yamaha Grizzly Stock Hitch (Off-Road, 2014).

Terrain Constraints

The terrain that the ATV mountable tree planting station will be operated on is somewhat rough. The land was once heavily forested but has been recently logged due to a pine bark beetle infestation and forest fire concerns. Having recently been logged, there are many stumps and the ground has been torn up from large logging tractors constantly traveling across it. The land also has many hills due to its location in the foothills of the Rocky Mountains. The land that will be planted can be seen in Figure 11.



Figure 11. Land to be Planted in Bozeman, MT (Google Maps, 2014).

Operator Constraints

A single operator must be able to easily and successfully use the machine. The intended use of this machine is for a person to drive the ATV while a second operator walks behind the tree planting station and operates the tree planting station when needed. This means that the auger must be easy and manageable for a single operator. The auger is held by a pivot arm that is counter balanced by a cable and large torsion spring. Virtually the auger should be close to weightless to operate. The final SolidWorks design of the ATV mountable tree planting station can be seen below in Figure 12.

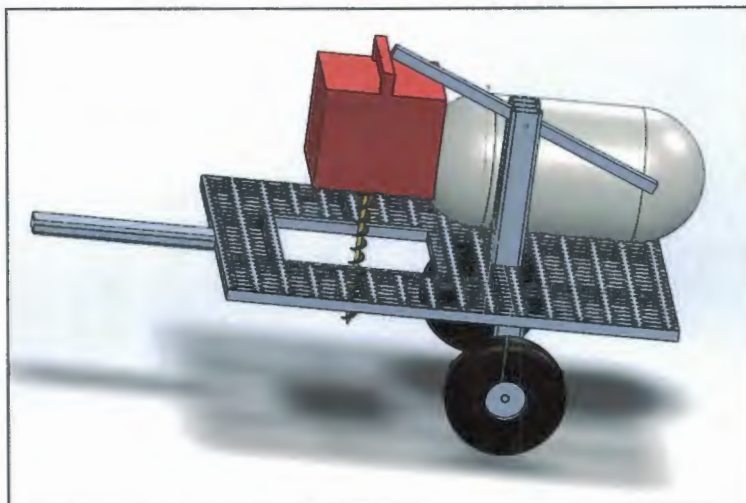


Figure 12. SolidWorks Design of Machine.

CONSTRUCTION PROCEDURE

The construction for this project occurred in BRAE shops 6 and 7, where the necessary equipment was easily accessible and readily available. All raw steel materials were purchased from B and B Steel in Santa Maria, CA. The design drawings were created in the BRAE computer lab with the aid of SolidWorks. The cut list of steel purchased can be seen below in table 1.

Table 1. Steel Cut List.

Steel Cut List			
Type	2" x 4" X .120"	1.5" X 1.5" X .120	Flat Expanded Steel (9 X 3/4")
Length	10'	20'	N/A
Area	N/A	N/A	4' X 8'
# Bought	2	2	1

All of the sticks of steel were cut to length with the use of a band saw. Ends that needed to be mitered were cut by tilting the band saw to a forty five degree angle and then making the cut. The mitered edges align so that once they are welded in place; there are no open ends that must have caps welded on. The band saw used can be seen below in Figure 13; this figure shows the band saw tilted at a forty five degree angle for a mitered cut on a 20 foot length of 1.5" square tubing.



Figure 13. Band Saw and 1.5" Square Tubing.

Once the pieces of the outer frame had been cut, they were clamped in place on top of a steel table. Once all angles and lengths were checked and deemed correct, the clamps were tightened so that the steel would not move and the welding could begin without fear of the metal warping due to the welds cooling. The metal pieces that were clamped in place can be seen below in Figure 14. This method was used often throughout the construction of this piece of equipment.



Figure 14. Squaring and Preparing to Weld.

A welded miter joint can be seen in Figure 15. For the welding of the frame of the trailer, a MIG welder with shielding gas was used. Once the welds cooled, the clamps were removed. All welds on the trailer frame were ground down and polished with the use of an angle grinder. This was done so that when the expanded steel is installed, it will remain flush with the frame at all locations.



Figure 15. Welded Joint.

The finished outer frame of the trailer can be seen below in figure 16 and the main cross member of the trailer can be seen in figure 17. Once all of the welds had cooled, the clamps were removed and the excess weld was ground off through the use of an angle grinder with a grinding disc. Once the excess welds had been roughly removed, a sanding/polishing disc was used to make the metal smooth.



Figure 16. Welded Outer Trailer Frame.



Figure 17. Welded Inner Frame Member.

The legs that the hubs and spindles were welded to were created by first cutting a section of 2" X 4" rectangular tubing, then drilling a one and a quarter inch hole through the member in the location that the spindle would be welded. A MIG welder was used to weld on the spindles. Welds were applied on the wheel side of the leg as well as the back side of the leg where the spindle butted up to the rectangular tubing.



Figure 18. Spindles/Hubs Welded to Trailer Legs.

A garage door spring and cable drum were mounted to the underside of the trailer to provide the needed counter force in order to make the operation of the auger virtually weightless. The garage door spring was tested under several different circumstances. The spring was twisted from 1 to 4.5 rotations and the resultant counter force provided was measured for each revolution with the use of a spring scale. The setup used for testing the force provided by the spring can be seen in Figure 19.



Figure 19. Garage Door Spring Test Setup.

A table of forces generated by the spring based on how many revolutions of pre-torque were applied can be seen below. All values were rounded to the nearest 5 lbs due to the inaccuracy of both the scale and the rotations of the spring.

Table 2. Garage Door Torsion Spring Forces.

Garage Door Torsion Spring Forces	
# of Revolutions	Force in Cable (lbs)
1	30
1.5	45
2	70
2.5	80
3	90
3.5	105
4	120
4.5	130

The garage door spring is 26.5 inches long, has a 2 inch inside diameter, and the wire is 0.250" in diameter. The spring will be attached to a cable drum and the cable from the drum will attach to the back end of the pivot arm holding the auger up. As the auger is lowered, the spring coils tighter, producing a force to counter act the weight and movement of the auger. When the auger is raised, the spring unwinds, retracting the cable back onto the drum. The spring, cable drum, and pivot arm can be seen in Figure 20.

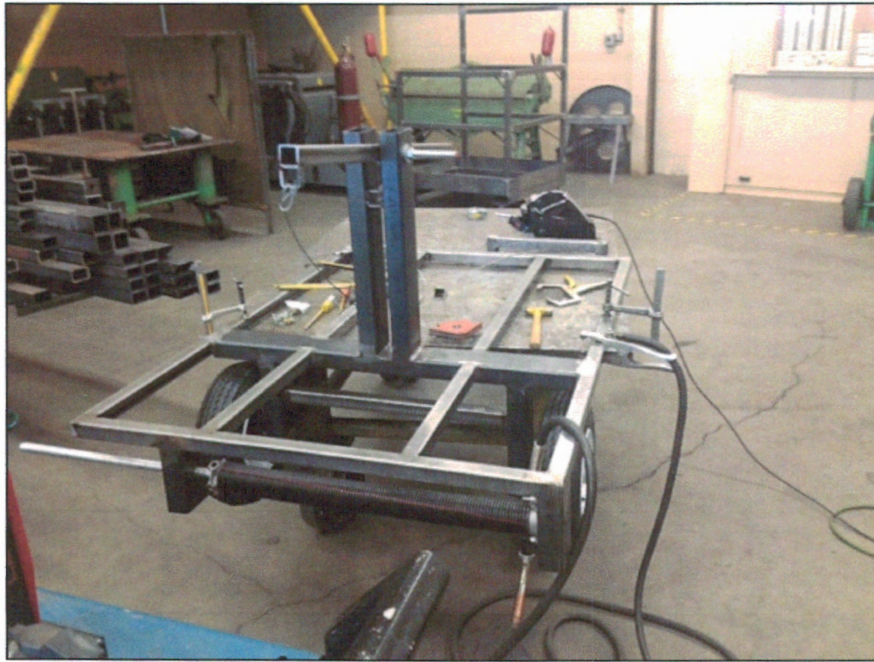


Figure 20. Spring, Cable Drum, and Pivot Arm.

Once the pivot arm and trailer were assembled and welded together, expanded steel was cut to length and welded on top of the trailer frame in order to provide a flat surface capable of carrying equipment on the trailer. A picture of the expanded steel and trailer can be seen in Figure 21. Once the expanded steel was placed on top of the trailer, a MIG welder was used to tack the outside of the expanded steel to the trailer frame so that it would remain in position and rigid.



Figure 21. Expanded Steel on Trailer Frame.

Once the trailer had been fully finished, a mount for the auger was designed and built based on the dimensions of the motor and a previously existing frame around the engine. The mount consists of a “C” shaped bracket that was “fish-mouthed” at the ends so it could be welded to the previously existing frame on the motor. In order to allow the motor to swing freely, weld-able hinges were used to attach the auger mount to the pivot arm. The auger mount and hinges can be seen below in Figure 22.



Figure 22. Weld-Able Hinges and Auger Mount.

Once the mount was welded to the auger bracket, the auger was hoisted and placed on the pivot arm. The garage door spring was torque until it provided the correct amount of force to keep the auger raised yet still allowed for the auger to be raised and lowered easily. Once the auger was placed on the pivot arm, the location of the hole that the auger would drill through was laid out and cut in the expanded steel with the use of a plasma cutter. The final trailer can be seen below in Figure 23.



Figure 23. Complete Trailer Set Up.

The construction phase of the project was completed once the water tank was attached and strapped to the trailer. The water tank is 15 gallons and utilizes a 12 volt DC pump to pressurize the water so that the wand sprayer works. The tank was strapped to the trailer through the use of two tie-downs that were hooked into the expanded steel. The finished product can be seen in Figure 24.



Figure 24. Complete ATV Mountable Tree Planting Station.

RESULTS

The ATV Mountable Tree Planting Station performed well. The auger was successfully held up by the pivot arm and the garage door spring provided a successful counter force to the augers weight. The correct number of rotations needed on the garage door spring in order to provide the correct tension on the back end of the pivot arm was 3.5 revolutions of the garage door spring before the set screws were tightened to the cable drum shaft. With 3.5 revolutions, the cable was applying a static force of 105 lbs to the back end of the pivot arm.

The operation of the auger on the counter tensioned system performed fairly well. It was found the auger could be lowered and raised with a small amount of effort. The hinges on the auger mount allowed for the auger bit to remain perpendicular with the ground as the device was raised and lowered. The friction in the cables, pulleys, and garage door spring provided enough resistance to keep the auger in place as it was moved up and down. This means that once the auger was lowered, it would remain down until the operator applied a small upward force to overcome the friction in the pulleys and spring, at which point the auger would easily raise and remain in position once it stopped.

One small problem with the auger counter balance system is that there is some “slop” in the pivot joint. A sideways force on the lever arm causes a slight deflection, not enough deflection to cause any problems, but enough that it warrants a closer look into a fix.

The auger was tested in several different soil types. The auger was tested in hard soil, medium-hard soil, and soft soil. A piece of tape was marked on the auger bit at 6 inches, in order to increase the accuracy of the measurements for the amount of time to dig a 6 inch deep hole. The data from the tests can be seen in the table below. The times shown in the tables represent the amount of time it took the auger to dig down 6 inches, once the bit made contact with the soil.

Table 3. Auger Tests.

Auger Tests			
Soil Type	Hard	Medium	Soft
Time to dig 6” hole	6.3 seconds	4.2 seconds	3.5 seconds
How it Felt (Force Needed)	Significant downward force needed	Some downward force needed	Very little downward force needed
Soil Characteristics	Soil was dry and had properties of a clay soil	Soil was dry and had properties of a clay loam soil	Soil was somewhat moist and had properties of a loam soil

The holes that were made by the auger were all fairly clean and could easily fit a tree sapling. The dirt removed from the auger holes was crumbly and could easily be re-inserted back into the hole. One of the holes created by the auger can be seen below in Figure 25.



Figure 25. Auger Hole.

DISCUSSION

The ATV Mountable Tree Planting Station performed satisfactorily when compared to the objectives of this project. The main objective of this project was to decrease the amount of manual labor associated with planting pine tree saplings. This project accomplished that task by providing an easy way to dig a hole and providing loose dirt to be re-packed around the newly planted pine tree. The ring stand on the trailer also provided a way of carrying bulk amounts of pine trees as the trailer is moved throughout a field. The water tank with sprayer has enough spare length in the spray line that any tree around the trailer can easily be reached and applying water and fertilizer will be simple.

While the project performed as it was intended to, there were some unexpected difficulties in the construction of the project. The first difficulty was the length of the garage door spring; the initial design included a spring that ended at the midpoint of the trailer, where the back end of the pivot arm was located. The correct size spring, with the needed OD and wire gauge was sold only in lengths that were longer than half the trailer width. The garage door spring extended from the right side of the trailer past the center line of the trailer (where the pivot arm was located) as can be seen in Figure 26, making it impossible to run the cable from the cable drum directly to the pivot arm. A picture of the actual trailer frame and spring can be seen in Figure 27. The solution to this problem was to weld two pulleys underneath the trailer in key locations to route the cable back towards the center of the trailer and provide the correct angle and direction to the pivot arm.

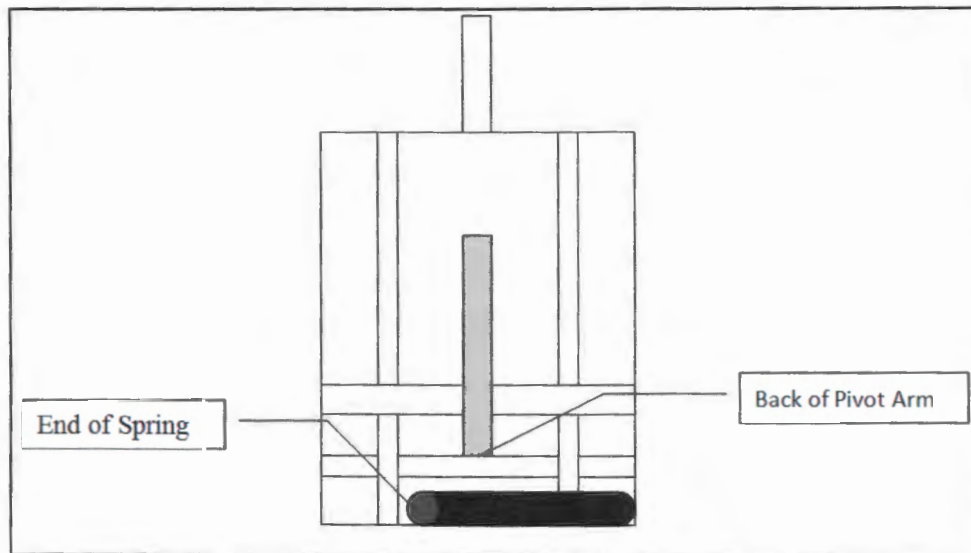


Figure 26. Spring and Pivot Arm Diagram.



Figure 27. Trailer and Spring.

In order to accommodate welding the pulleys to the bottom of the trailer, cross members were added to the back of trailer frame to provide the correct location for the pulleys to be welded. Once the pulleys were welded in place, the cable from the cable drum was directed through the pulleys and attached to the pivot arm in a clear unobstructed line. The pulley system and cross members can be seen in Figure 28.



Figure 28. Pulley System and Cross Members.

A concern regarding the design of the auger on a pivot arm was that the auger would move laterally as it was lowered into the ground. A diagram of the movement of the pivot arm can be found in Figure 29. The pivot arm was designed to minimize the amount of lateral movement while still giving the auger a large vertical movement to allow for deeper holes to be dug if necessary. Testing the auger on the pivot arm proved that there were no implications to the auger being on a pivot and that it could in fact dig a straight hole. The auger had some movement towards the pivoting joint as it was being lowered, but not enough to cause any significant problems in this scenario of use.

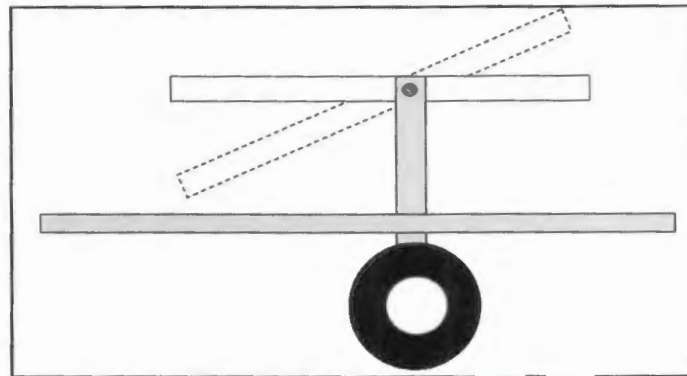


Figure 29. Diagram of Pivot Arm Movement.

The auger did a good job of digging a hole in soil and it did it in a fairly quick amount of time. As can be seen in the “Auger Tests” Table, even in harder soils the auger performed well and succeeded in providing a space for a new sapling tree to be planted. The auger bit used in the test was three inches in diameter but the ATV Mountable Tree Planting Station setup can accommodate an auger bit up to a diameter of ten inches. If larger trees were to be planted, a larger bit could easily be swapped out with the three inch bit and the trailer and auguring device would function the same.

Overall the device seems to be operating as was hoped at the beginning of the project. It functioned properly in all of the tests that it was subjected to. The ATV Mountable Tree Planting Station will be put into operation and used in the field in June 2014.

RECOMMENDATIONS

If this project were to be reconstructed or redesigned, there are several recommendations that could be made to improve the overall design. While the design does perform satisfactorily and meets all of the project objectives, there are minor adjustments that could be made.

The first recommendation would be to add bearings to the pivot arm. With the use of bearings there would be much less friction in the pivot arm joint and the operation of the auger on the pivot arm would be much smoother. Currently the joint consists of a hole drilled through each of the members and a smooth rod with clips and washers on both ends is used to hold the pivot arm in place. The metal on metal contact works fine for the situation in which it is being used, but there is an amount of friction that would not be there if bearings were to be used in place of it.

The design could easily be modified as is to accommodate bearings in the pivot design. Flange bearings could easily be mounted to the outsides of the uprights in the pivot system and the smooth rod could rest in the bearings as opposed to having metal on metal contact. In order to implement this into the design, holes would need to be drilled and tapped into the sides of the pivot uprights and then bearings could be mounted.

The second recommendation would be to buy higher quality pulleys and use vinyl coated cable. The pulleys that were used to redirect the cable from the cable drum to the pivot arm are not high quality and as a result there is an amount of friction in them that cannot be avoided given the forces that they are experiencing. The cable that was first used on the cable drum was an uncoated steel cable. The interaction between the uncoated steel cable and the pulleys was very noticeable. There was a noticeable amount of friction between the cable and the pulleys as well as a slight grinding noise when the pivot was raised and lowered.

A vinyl coated steel cable was purchased and used in place of the uncoated cable, the difference was noticeable immediately. The grinding noise was completely eliminated and there was a significant reduction in the amount of friction between the cables and pulleys. With the purchase of higher quality pulleys, the amount of friction will most likely decrease a significant amount more.

A third recommendation to be made would be to reinforce the pivot uprights. When the pivot arm experiences a sideways load, the force felt by the pivot uprights causes a slight deflection. In order to reduce the size of this deflection, the pivot uprights should be reinforced and welded together in a middle location that will not affect the motion of the pivot arm. The location of the joint can be seen in Figure 30.

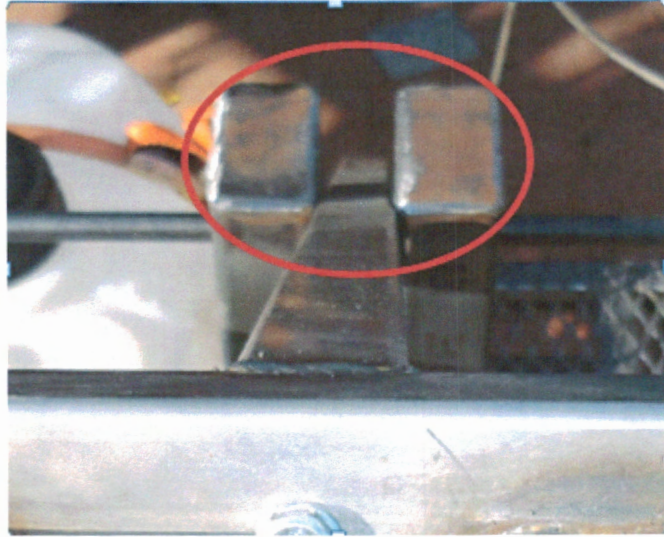


Figure 30. "Sloppy" Pivot Joint.

COST ANALYSIS

Table 4. Cost Analysis.

Cost Analysis			
Item	Price	Amount	Total
Ardisam 4-Stroke Earth Auger	\$ 379.99	1	\$ 379.99
Tie Down Engineering 4-Lug Hub/Spindle Unit	\$ 49.99	2	\$ 99.98
4 Hole High Speed Standard Rim Trailer Tire (16" dia.)	\$ 49.99	2	\$ 99.98
1.5" Square Tubing (.120 Wall Thickness) per foot	\$ 2.15	40	\$ 86.00
Garage Door Spring Setup	\$ 58.95	1	\$ 58.95
Cable Drum	\$ 25.00	1	\$ 25.00
Weld-able Hinges	\$ 7.50	2	\$ 15.00
2" X 4" Rectangular Tubing (.120 Wall Thickness) per foot	\$ 2.25	20	\$ 45.00
Ardisam Earth Auger Bit (3")	\$ 119.99	1	\$ 119.99
3/4" X 9 Expanded Steel (4' X 8' Sheet)	\$ 57.00	1	\$ 57.00
Water Tank	\$ 59.99	1	\$ 59.99
Steel Cable	\$ 0.33	9	\$ 2.97
Cable Clamps	\$ 2.99	1	\$ 2.99
Torsion Spring Axle	\$ 3.99	4	\$ 15.96
Ring Stand Metal	\$ 4.99	2	\$ 9.98
Shop Consumables	\$ 25.00	1	\$ 25.00
Fabrication/Welding Labor	\$ 75.00	35	\$ 2,625.00

Total

\$ 3,728.78

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APPENDICES

APPENDIX A

HOW PROJECT MEETS REQUIREMENTS FOR THE BRAE MAJOR

Major Design Experience

Establishment of Objectives and Criteria

Project objectives and criteria are established to meet the needs of reforestation of an area of land that has recently been logged

Synthesis and Analysis

The project will incorporate bending stress calculations, tests of different soils, and consideration of planting in different soil types

Construction, Testing and Evaluation

The mechanized mobile tree sapling planter will be designed and constructed.

Incorporation of Applicable Engineering Standards

The project will utilize AISC standards for allowable bending stresses.

Capstone Design Experience

Incorporates knowledge/ skills from these key courses- BRAE 129 Lab Skills/Safety, BRAE 133 Engineering Graphics, BRAE 151 AutoCAD, BRAE 152 SolidWorks, BRAE 234 Mechanical Systems, BRAE 421/422 Equipment Engineering, Engineering Statics/Dynamics, Strength of Materials, Technical Writing

Physical- The implement must attach to an ATV. It must plant six inch tall trees directly into the soil with as little operator effort as possible.

Economic- The cost of operation must not exceed the price of gas for the ATV

Environmental- A benefit of the project will be that lands that were once logged will be replanted with saplings. The environment will benefit as a result.

Sustainability- The sapling planter will help to sustain the environment through reforestation of lands that have been logged

Manufacturability- N/A

Health and Safety- The mobile tree sapling planter will utilize safety precautions on areas of the device that may pose a safety hazard to the operator or bystanders.

Ethical- N/A

Social- N/A

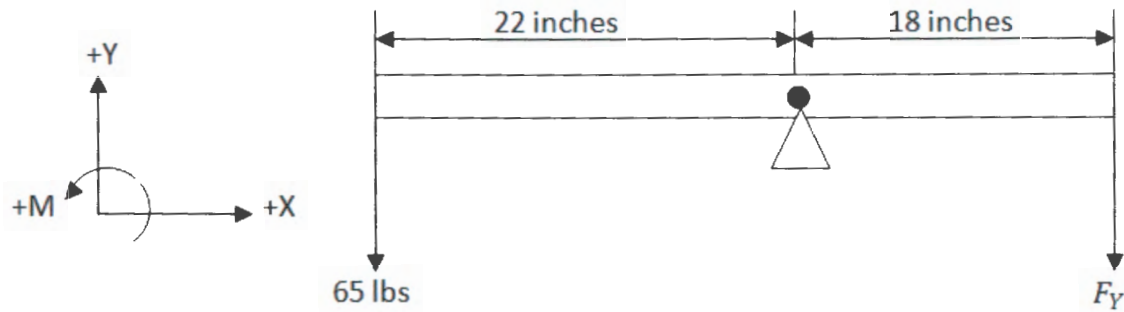
Political- Reforestation of the environment.

Aesthetic- The finished machine will be painted to look very nice. High quality protective paint will be used due to the rough environment in which the implement will operate.

Other – Productivity- The implement must be capable of planting tree saplings at a constant depth given variable soil conditions.

APPENDIX B

CALCULATIONS AND DESIGN FOR PIVOT ARM



$$\sum M_o = 0$$

$$\sum M_o = (65 \text{ lbs})(22 \text{ inches}) - (F_Y)(18 \text{ inches}) = 0$$

$$F_Y = \frac{(65 \text{ lbs})(22 \text{ inches})}{(18 \text{ inches})}$$

$$F_Y = 79.4 \text{ lbs}$$

Therefore the spring must provide a minimum F_Y of 79.4 lbs

Accounting for various friction losses in the spring, cable drum, cable, pulleys, and pivot joint, and additional 20 lbs of force will be added to the minimum F_Y value for a total value of 99.4 lbs.

$$F_{Y \text{ NEW}} = 99.4 \text{ lbs}$$

APPENDIX C

OPERATIONS MANUAL FOR ARDISAM BRIGGS AND STRATTON EARTH AUGER

Earthquake

Operator's Manual
Original Operating Instructions

**Two-Person
Earth Auger Powerhead
9800 Series**



Includes models:
9800B (Shown)
9800H

Get parts online at
www.GetEarthquake.com

P/N: CM9800B
Revised 06/16/11

INTRODUCTION

Congratulations on your investment in quality. Thank you for purchasing an Earthquake Two-Person Auger Powerhead. We have worked to ensure that the auger meets the highest standards for usability and durability. With proper care, your auger will provide many years of service.

Please read this entire manual before installation and use. Earthquake reserves the right to change, alter or improve the product and this document at any time without prior notice.

CONTENTS

Introduction/Contents/Registration	2
Warnings and Safety Precautions	3-6
Assembly	7
Operation	7-8
Maintenance and Storage	9-10
Troubleshooting and Repair	10-11
Parts Breakdown	12-14
Warranty	15

REGISTRATION, SERVICE AND MAINTENANCE LOG

Record the model number and serial number in the space provided for easy reference. Warranty is valid only if the completed registration is received by Earthquake within 30 days of purchase. You can register your warranty online by visiting www.getearthquake.com. If you do not have a computer, call our customer service department at (800) 345-6007 Mondays through Fridays from 8 a.m. to 5 p.m. CST.

OWNERSHIP RECORDS		
Owner's Name:		
Owner's Address:		
City:	State/Province:	Zip Code/Postal Code:
Model Number:	Serial Number:	
Date of Purchase:		
Notes:		

This manual contains information for several models. Read and keep this manual for future reference. This manual contains important information on SAFETY, ASSEMBLY, OPERATION, AND MAINTENANCE. The owner must be certain that all the product information is included with the unit. This information includes the INSTRUCTION BOOKS, the REPLACEMENT PARTS and the WARRANTIES. This information must be included to make sure state laws and other laws are followed.

WARNINGS AND SAFETY PRECAUTIONS

OPERATOR'S RESPONSIBILITY

Accurate assembly and safe and effective use of the machine is the operator's responsibility.

- Read and follow all safety instructions.
- Carefully follow all assembly instructions.
- Maintain the machine according to directions and schedule included in this Earthquake operator's manual.
- Ensure that anyone who uses the machine is familiar with all controls and safety precautions.

SPECIAL SAFETY MESSAGES

Your manual contains special messages to bring attention to potential safety concerns, machine damage as well as helpful operating and servicing information. Please read all the information carefully to avoid injury and machine damage.

NOTE: General information is given throughout the manual that may help the operator in the operation or service of the machine.



This symbol points out important safety instructions which if not followed could endanger your personal safety. Read and follow all instructions in this manual before attempting to operate this equipment.

BEFORE OPERATING ENGINE:

Please read this section carefully. Read entire operating and maintenance instructions AND the instructions in the engine manual that accompanies this product (if applicable). Failure to follow instructions could result in serious injury or death. Operate the machine according to the safety instructions outlined here and inserted throughout the text. Anyone who uses this machine must read the instructions and be familiar with the controls.



WARNING

WARNING INDICATES A HAZARD WHICH, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY AND/OR PROPERTY DAMAGE.



CAUTION

CAUTION INDICATES YOU CAN BE HURT OR YOUR EQUIPMENT DAMAGED IF THE SAFETY INSTRUCTIONS THAT FOLLOW THIS SIGNAL WORD ARE NOT OBEYED.



IMPORTANT

INDICATES HELPFUL INFORMATION FOR PROPER ASSEMBLY, OPERATION, OR MAINTENANCE OF YOUR EQUIPMENT.



WARNING

CALIFORNIA PROPOSITION 65 WARNING

ENGINE EXHAUST FROM THIS PRODUCT CONTAINS CHEMICALS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, BIRTH DEFECTS, OR OTHER REPRODUCTIVE HARM.



WARNING

YOU MUST READ, UNDERSTAND AND COMPLY WITH ALL SAFETY AND OPERATING INSTRUCTIONS IN THIS MANUAL BEFORE ATTEMPTING TO SETUP AND OPERATE YOUR MACHINE.

FAILURE TO COMPLY WITH ALL SAFETY AND OPERATING INSTRUCTIONS CAN RESULT IN LOSS OF MACHINE CONTROL, SERIOUS PERSONAL INJURY TO YOU AND/OR BYSTANDERS, AND RISK OF EQUIPMENT AND PROPERTY DAMAGE. THE TRIANGLE IN THE TEXT SIGNIFIES IMPORTANT CAUTIONS OR WARNINGS WHICH MUST BE FOLLOWED.



Intended Use / Foreseeable Misuse

This is a motorized earth auger that drills into soil. It is pedestrian controlled. It has a petrol-fuelled internal combustion engine that powers the auger blades. It shall not be used for any other purpose.

GENERAL SAFETY RULES

- Read, understand, and follow all instructions on the machine and in the manual(s). Be thoroughly familiar with the controls and the proper use of the machine before starting.
- Use this equipment for its intended purpose only.
- Familiarize yourself with all of the safety and operating decals on this equipment and on any of its attachments or accessories.
- Do not put hands or feet near or under rotating parts.
- Only allow responsible individuals who are familiar with the instructions to operate the machine. Do not allow children to operate this machine. Do not allow adults to operate the machine without proper instruction.
- Thoroughly inspect the area where the machine is to be used and remove all foreign objects. Your equipment can propel small objects at high speed causing personal injury or property damage. Stay away from breakable objects, such as house windows, automobile, greenhouses, etc.
- Wear appropriate clothing such as a long-sleeved shirt or jacket. Also wear long trousers or slacks. Do not wear shorts. Never wear sandals, sneakers, or open shoes, and never operate the machine with bare feet.
- Do not wear loose clothing or jewelry. They can get caught in moving parts. Always keep hands, feet, hair and loose clothing away from any moving parts on engine and machine.
- Always wear safety goggles or safety glasses with side shields when operating the machine to protect your eyes from foreign objects which can be thrown from the unit. Always wear a protective hearing device.
- Always wear work gloves and sturdy footwear. Wear footwear that will improve footing on slippery surfaces. Leather work shoes or short boots work well for most people. These will protect the operator's ankles and shins from small sticks, splinters, and other debris.
- It is advisable to wear protective headgear to prevent the possibility of being struck by small flying particles, or being struck by low hanging branches, twigs, or other objects which may be unnoticed by the operator.
- Do not operate the machine without proper guards or other safety protective devices in place.
- See manufacturer's instructions for proper operation and installation of accessories. Only use accessories approved by the manufacturer.
- Operate only in daylight or good artificial light.
- Do not operate product when fatigued or under the influence of alcohol, drugs or other medication which can cause drowsiness or affect your ability to operate this machine safely.
- Never operate machine in wet grass. Always be sure of your footing; keep a firm hold on the handle and walk; never run.
- Watch for traffic when operating near, or when crossing roads.
- If the equipment should start to vibrate abnormally, stop the engine (motor), disconnect the spark plug wire and prevent it from touching the spark plug. Check immediately for cause. Vibration is generally a warning of trouble. If the noise or vibrations of the machine increase, stop immediately and perform an inspection.
- Never leave the machine unattended when the engine is running. Remove the wire from the spark plug.
- Regularly inspect the machine. Make sure parts are not bent, damaged or loose.
- Temperature of muffler and nearby areas may exceed 150°F (65°C). Allow muffler and engine area to cool before touching. Never pick up or carry the machine while the engine is running.
- Prolonged exposure to noise and vibration from gasoline engine-powered equipment should be avoided. Take intermittent breaks and/or wear ear protection from engine noise as well as heavy work gloves to reduce vibration in the hands.
- Keep all screws, nuts and bolts tight.
- Do not transport the machine from one place to another with the engine running.
- When moving the packaged machine, always do so with a partner.
- Check local regulations for age restrictions on use of this machine.

PRODUCT-SPECIFIC SAFETY RULES

- Do not drill above underground utilities, including water lines, gas lines, electric cables, or pipes. Do not operate the auger in soil with large rocks and foreign objects which can damage the equipment.
- After striking a foreign object, stop the engine. Remove the wire from the spark plug. Inspect the auger for damage. If damaged, repair before starting and operating the auger.
- The blades of the auger should not rotate when the engine is idling. If it does rotate when engine is idling, contact Earthquake for instructions.
- If an object becomes lodged in the auger, turn engine off, remove the wire from the spark plug and secure, allow to cool before attempting to remove the foreign object.
- The earth blade is very sharp. Use extreme caution when drilling a hole or replacing the blade.
- Do not carry the earth auger unit between holes with the engine running.

ENGINE SAFETY PRECAUTIONS**Warning Carbon Monoxide Poisoning**

Engines give off carbon monoxide, an odorless, colorless, poison gas. Carbon monoxide may be present even if you do not smell or see any engine exhaust. Breathing carbon monoxide can cause nausea, fainting or death, in addition to drowsiness, dizziness and confusion. If you experience any of these symptoms, seek fresh air and medical attention immediately.

If your product comes with a separate engine manual, be sure to read and follow all safety and warning precautions outlined there, in addition to any in this manual.

Preventing Carbon Monoxide Poisoning

- Always start and run engine outdoors. Do not start or run engine in an enclosed area, even if doors or windows are open.
- Never try to ventilate engine exhaust indoors. Carbon monoxide can reach dangerous levels very quickly.
- Never run engine outdoors where exhaust fumes may be pulled into a building.
- Never run engine outdoors in a poorly ventilated area where the exhaust fumes may be trapped and not easily taken away. (Examples include: in a large hole or areas where hills surround your working area.)
- Never run engine in an enclosed or partially enclosed area. (Examples include: buildings that are enclosed on one or more sides, under tents, car ports or basements.)
- Always run the engine with the exhaust and muffler pointed in the direction away from the operator.
- Never point the exhaust muffler towards anyone. People should always be many feet away from the operation of the engine and its attachments.
- Do not change the engine governor settings or over-speed the engine.

Gasoline Fires and Handling Fuel Safely

Use extra care in handling gasoline and other fuels. They are flammable and vapors are explosive.

- When storing extra fuel be sure that it is in an appropriate container and away from any fire hazards.
- Prevent fire and explosion caused by static electric discharge. Use only nonmetal, portable fuel containers approved by the Underwriter's Laboratory (U.L.) or the American Society for Testing & Materials (ASTM).
- Always fill fuel tank outside in a well ventilated area. Never fill your fuel tank with fuel indoors. (Examples include: basement, garage, barn, shed, house, porch, etc.) Never fill tank near appliances with pilot lights, heaters, or other

**WARNING**

ENGINES GIVE OFF CARBON MONOXIDE, AN ODORLESS, COLORLESS, POISON GAS. CARBON MONOXIDE MAY BE PRESENT EVEN IF YOU DO NOT SMELL OR SEE ANY ENGINE EXHAUST. BREATHING CARBON MONOXIDE CAN CAUSE NAUSEA, FAINTING OR DEATH, IN ADDITION TO DROWSINESS, DIZZINESS AND CONFUSION.

IF YOU EXPERIENCE ANY OF THESE SYMPTOMS, SEEK FRESH AIR AND MEDICAL ATTENTION IMMEDIATELY.

**CAUTION**

HOT GASES ARE A NORMAL BY-PRODUCT OF A FUNCTIONING CATALYTIC CONVERTER. FOLLOW ALL SAFETY INSTRUCTIONS TO PREVENT BURNS AND FIRES.

DO NOT ALTER/MODIFY ENGINE:

NEVER ALTER OR MODIFY THE ENGINE FROM THE FACTORY. SERIOUS INJURY OR DEATH MAY OCCUR IF ENGINE IS MODIFIED OR ALTERED.

WHEN WORKING ON OR REPLACING PARTS FOR THE ENGINE OR PRODUCT, YOU MUST ALWAYS DISCONNECT SPARK PLUG WIRE FROM THE SPARK PLUG AND KEEP IT AWAY FROM THE SPARK PLUG.

Ignition sources. If the fuel has to be drained, this should be done outdoors. The drained fuel should be stored in a container specifically designed for fuel storage or it should be disposed of carefully.

- Never remove the fuel cap or add fuel with the engine running. Stop engine and allow to cool before filling.
- Do not smoke.
- Never drain fuel from engine in an enclosed area.
- Always wipe up excess (spilled) fuel from engine before starting. Clean up spilled fuel immediately. If fuel is spilled, do not start the engine but move product and fuel container from area. Clean up spilled fuel and allow to evaporate and dry after wiping and before starting.
- Allow fuel fumes/vapors to escape from the area before starting engine.
- Test the fuel cap for proper installation before starting and using engine.
- Always run the engine with fuel cap properly installed on the engine.
- Always unscrew gas cap vent screw while engine is running.
- Never smoke while refilling engine fuel tank.

- Do not store engine with fuel in fuel tank indoors. Fire and fuel vapors are highly explosive.
- During storage, screw down gas cap vent screw tightly.
- Never pour fuel from engine fuel tank.
- Never siphon fuel by mouth to drain fuel tank.
- Always have an adult fill the fuel tank and never allow children to fill the engine.
- Never allow an adult or anyone under the influence of drugs or alcohol to fill engine.
- When storing gasoline or equipment with fuel in the tank, store away from furnaces, stoves, water heaters or other appliances that have a pilot light or other ignition source because they can ignite gasoline vapors.

BURNS AND FIRES

The muffler, muffler guard and other parts of the engine become extremely hot during the operation of the engine. These parts remain extremely hot after the engine has stopped.

Prevention of Burns and Fires

- Never remove the muffler guard from the engine.
- Never touch the muffler guard because it is extremely hot and will cause severe burns.
- Never touch parts of the engine that become hot after operation.
- Always keep materials and debris away from muffler guard and other hot parts of the engine to avoid fires.
- This engine is designed to operate using a catalytic converter which contributes to the engine's compliance with the EPA.

CHILDREN AND BYSTANDERS

Tagg accidents can occur if the operator is not alert to the presence of children and/or bystanders. Never assume that others will remain where you last saw them.

- Keep the area of operation clear of all persons, especially small children and pets. Keep children under the watchful care of a responsible adult.
- Be alert and turn machine off if children enter the area.
- Before and while moving backwards, look behind and down for small children.
- Never allow children to operate the machine.
- Use extra care when approaching blind corners, shrubs, trees or other objects that may obstruct vision.

SERVICE

- Always stop the engine whenever you leave the equipment, before cleaning, repairing or inspecting the unit. Engine should be turned off and cool, spark plug wire must be removed from spark plug before any repairs or adjustments are attempted. Never make adjustments or repairs with the engine (motor) running. Disconnect the spark plug wire, and keep the wire away from the plug to prevent accidental starting. Remove the ignition key if equipped with an electric start.
- Always wear eye protection when you make adjustments or repairs.
- Keep all nuts and bolts tight and keep equipment in good condition.
- Never tamper with safety devices. Check their proper operation regularly.
- When servicing or repairing the machine, do not tip the machine over or up unless specifically instructed to do so in this manual. Service and repair procedures can be done with the machine in an upright position. Some procedures will be easier if the machine is lifted on a raised platform or working surface.
- To reduce fire hazard, keep machine free of grass, leaves, or other debris build-up. Clean up oil or fuel spillage. Allow machine to cool before storing.
- Stop and inspect the equipment if you strike an object. Repair, if necessary, before re-starting.
- Clean and replace safety and instruction decals as necessary.
- To guard against engine over-heating, always have engine debris filter mounted and clear.
- Inspect machine before storage. When not in use, disconnect spark plug lead and store indoors in a dry place locked or otherwise inaccessible to children.
- Use only original equipment parts from Earthquake, including all nuts and bolts.

ASSEMBLY**UNPACK POWERHEAD**

1. Carefully lift the powerhead out of the box, remove any packing material and cut any ties.

TOOLS REQUIRED

- Two (2) 9/16" Wrenches

ASSEMBLY INSTRUCTIONS

1. Insert the output shaft of the transmission in the open end of the Flex Coil ShockTop.
2. Line up the bolt holes through the Flex Coil ShockTop and the output shaft of the transmission.
3. Place the included 3/8-16 x 1.5 inch bolt through the bolt hole.
4. Hand-thread the 3/8-16 "B-way" lock nut on the bolt.
5. Using two 9/16 inch wrenches, securely tighten the nut and bolt.

OPERATION**PRE-START CHECKLIST**

1. Read and understand the operator's manual that came with your unit and the engine.
2. Fill oil sump or check oil level. Check oil level often during engine break-in.
3. Fill fuel tank. Use unleaded, regular gasoline.
4. Be sure spark plug wire is attached to spark plug.

PREPARING ENGINE FOR STARTING**TO CHECK THE OIL**

- Check the engine oil level with the engine stopped and in a level position.
- Remove the oil filler cap/dipstick and wipe it clean.
- Insert the oil filler cap/dipstick into the oil filler neck, but do not screw it in; then remove it to check the oil level.
- If the oil level is near or below the lower limit mark on the dipstick, fill with the recommended oil to the upper limit mark. Do not overfill.
- Reinstall the oil filler cap/dipstick.

FUEL RECOMMENDATIONS

Use clean, fresh, regular unleaded gasoline with a minimum of 85 octane.

- These engines are certified to operate on unleaded gasoline. Unleaded gasoline produces fewer engine and spark plug deposits and extends exhaust system life.
- Never use stale or contaminated gasoline or an oil/gasoline mixture. Avoid getting dirt or water in the fuel tank.
- Occasionally, you may hear a light "spark knock" or "pinging."

**CAUTION**

DO NOT START YOUR EARTH AUGER UNIT UNTIL YOU HAVE READ THE ENGINE MANUAL THAT CAME WITH YOUR ENGINE, AND THE "WARNINGS AND SAFETY PRECAUTIONS" SECTION IN THIS MANUAL. IF YOU HAVE READ THESE, FOLLOW THE STEPS TO START YOUR EARTH AUGER UNIT. ALWAYS PERFORM PRE-START CHECKLIST BEFORE STARTING THE ENGINE.

IT IS RECOMMENDED THAT THE EARTH AUGER UNIT NOT BE TILTED AT MORE THAN A 30 DEGREE ANGLE FROM THE UPRIGHT POSITION. FAILURE TO DO SO CAN CAUSE FUEL AND/OR OIL LEAKAGE.

**CAUTION**

NEVER ADD GAS WHEN ENGINE IS RUNNING OR HOT FROM OPERATION. NEVER FILL THE TANK IN DOORS. DO NOT SMOKE WHEN FILLING FUEL TANK.

NEVER FILL FUEL TANK COMPLETELY. FILL TANK TO 1/2" BELOW BOTTOM OF FILLER NECK TO PROVIDE SPACE FOR FUEL EXPANSION. WIPE ANY FUEL SPILLAGE FROM ENGINE AND EQUIPMENT BEFORE STARTING ENGINE.

DO NOT HOLD THROTTLE LEVER WIDE OPEN WHILE STARTING. LOSS OF CONTROL OF POWERHEAD/AUGER COULD RESULT.

NEVER RUN ENGINE INDOORS OR IN ENCLOSED, POORLY VENTILATED AREAS. ENGINE EXHAUST CONTAINS CARBON MONOXIDE, AN ODORLESS AND DEADLY GAS.

KEEP HANDS, FEET, HAIR AND LOOSE CLOTHING AWAY FROM ANY MOVING PARTS ON ENGINE AND EQUIPMENT.

TEMPERATURE OF MUFFLER AND NEARBY AREAS MAY EXCEED 150° F. AVOID THESE AREAS.

BEFORE STORING UNIT, DISCONNECT SPARK PLUG WIRE FROM SPARK PLUG AND ATTACH IT TO RETAINING POST.

NEVER STORE ENGINE WITH FUEL IN TANK INDOORS OR IN ENCLOSED, POORLY VENTILATED AREAS, WHERE FUEL FUMES MAY REACH AN OPEN FLAME, SPARK OR PILOT LIGHT.

**IMPORTANT**

NEVER MIX OIL WITH GASOLINE.

(metallic rapping noise) while operating under heavy loads. This is no cause for concern.

- If spark knock or pinging occurs at a steady engine speed, under a normal load, change gasoline brands. If spark knock or pinging persists, see an authorized servicing dealer.

FILLING FUEL TANK

1. Shut-off engine and allow engine to completely cool before refilling the gas tank.
2. Move to a well-ventilated area, outdoors, away from flames and sparks.
3. Clean debris from area around the gas cap.
4. Loosen gas cap slowly. Place the cap on a clean, dry surface.
5. Carefully add fuel without spilling.
6. Do not fill gas tank completely full; allow space for fuel to expand.
7. Immediately replace gas cap and tighten. Wipe off spilled fuel and allow to dry before starting engine.

IMPORTANT OPERATION NOTES

1. Read engine manual and follow instructions for fuel type, starting, etc.
2. The clutch will transfer maximum power after about two hours of normal operation. During this break-in period clutch slippage may occur. The clutch should be kept free of oil or other moisture for efficient operation.
3. The earth auger unit should be operated no more than 20 degrees in any direction during continuous use, an limited to 30 degrees intermittently. This is recommended for adequate lubrication and fuel delivery.
4. When digging in heavy soil, lift the earth auger unit out of the hole once for every one foot of depth.
5. Never run engine indoors. Exhaust fumes are deadly.
6. Do not use an earth auger in ice.
7. Drill holes without placing excessive body weight on the unit. The auger operates most efficiently with a shaving action caused by the weight of the unit itself.

STARTING AND STOPPING ENGINE TO START ENGINE:

1. Open fuel shut-off valve.
2. Flip the on/off switch to **ON** position.
3. Move choke lever to the **CHOKE** position.

NOTE: Do not use the choke to restart a warm engine after a short shutdown.

4. Grasp starter handle and pull rope out, slowly, until it pulls slightly harder. Let rope rewind slowly. Then pull rope with a rapid full arm stroke. Let rope return to starter slowly.

WARNING

MAKE SURE THE UNIT IS IN A STABLE POSITION BEFORE PULLING THE STARTER HANDLE.

WHEN THE UNIT STARTS TO FIRE OR RUN, RELEASE THE THROTTLE CONTROL MOMENTARILY WITH YOUR RIGHT HAND AND RETURN YOUR LEFT HAND TO THE HANDLEBAR POSITION TO MAINTAIN CONTROL AND STABILITY OF THE UNIT WITH BOTH HANDS.

CAUTION

ALWAYS HANDLE FUEL IN A WELL VENTILATED AREA, OUTDOORS, AWAY FROM FLAMES OR SPARKS.

DO NOT START ENGINE IF FUEL IS SPILLED. WIPE OFF EXCESS FUEL AND ALLOW TO DRY. REMOVE ENGINE FROM AREA TO AVOID SPARKS.

TO PREVENT ACCIDENTAL STARTING, ENGINE MUST BE TURNED OFF AND COOL, AND SPARK PLUG WIRE MUST BE REMOVED FROM SPARK PLUG BEFORE CHECKING AND ADJUSTING ENGINE OR EQUIPMENT.

DO NOT OPERATE AUGER BEFORE READING THE ENGINE MANUAL PROVIDED IN THE PARTS PACKET.

ALWAYS WEAR A PROTECTIVE HEARING DEVICE.

IF AUGER IS MOUNTED TO ENGINE, ALL SAFETY GUARDS MUST BE SECURELY ON TO AVOID SERIOUS INJURY.

STARTER ROPE CAN CAUSE AN UNANTICIPATED JERK TOWARDS ENGINE. PLEASE FOLLOW INSTRUCTIONS TO AVOID INJURY.

IF ENGINE FAILS TO START AFTER TRYING STARTING PROCEDURES, PLEASE CONTACT OUR CUSTOMER SERVICE DEPARTMENT AT 800-345-6007.

NEVER LEAVE ENGINE RUNNING WHILE UNATTENDED. TURN OFF AFTER EVERY USE.

NEVER CARRY POWERHEAD AND AUGER BETWEEN HOLES WHILE ENGINE IS RUNNING.

IMPORTANT

ENGINE CAN OVERHEAT AND BECOME DAMAGED IF DEBRIS BLOCKS THE COOLING FINS OR RECOIL HOUSING.

NEVER RUN ENGINE WITHOUT COMPLETE AIR CLEANER INSTALLED ON ENGINE.

5. When engine fires or starts running, gradually move the choke lever back to the **RUN** position.

TO STOP ENGINE

1. Flip the on/off switch to the **OFF** position.
2. Close fuel shut-off valve.

MAINTENANCE AND STORAGE

POWER AUGER MAINTENANCE

1. The gear case has 4 oz. of grease installed at the factory. It is recommended that once a year the gear case be split and the grease level checked. Add grease only if level of grease is below top of the gears. **DO NOT OVERFILL.**
2. Keep all screws, nuts, and bolts tight.
3. For cold weather operation, store the unit in a cool environment. Transferring the unit from a warm to a cold place can cause the build up of harmful condensation.
4. If blade performance decreases, turn unit off and disconnect spark plug wire. Carefully inspect cutting edge of blade for any signs of wear. If blades show any of these signs, they need to be sharpened or replaced.
5. Always allow muffler to cool before filling fuel tank.
6. When storing for over one month, use gas stabilizer in fuel.
7. Do not fill gas tank indoors or when engine is running or is hot.

ENGINE MAINTENANCE

Please read your engine manual and observe these recommendations to extend the life of your engine. Your engine manual provides detailed information and a maintenance schedule for performing the following tasks:

1. Check oil level every five (5) operating hours and before each use.
2. Change oil after first two (2) operating hours and every 25 operating hours thereafter, more often if operated in extremely dusty or dirty conditions. Change oil while engine is still warm from recent running.
3. Frequently remove dirt and debris from cooling fins, air intake screen, levers and linkage. This will help ensure adequate cooling and correct engine speed.
4. Check air cleaner.
5. Check spark plug yearly or every 100 operating hours.
6. Check engine and auger often for loose nuts and bolts.

Good maintenance is essential for safe, economical, and trouble-free operation. It will also help reduce air pollution. To help you properly care for your engine, read your engine manual and pay close attention to the maintenance schedule, routine inspection procedures, and simple maintenance procedures.

Other service tasks that are more difficult, or require special tools, are best handled by professionals and are normally performed by a technician or other qualified mechanic.



CAUTION

TO PREVENT ACCIDENTAL STARTING:

ENGINE MUST BE TURNED OFF AND COOL, AND SPARK PLUG WIRE MUST BE REMOVED FROM SPARK PLUG BEFORE CHECKING AND ADJUSTING ENGINE OR EQUIPMENT.

CHECK AUGER OFTEN FOR LOOSE NUTS AND BOLTS. KEEP THESE ITEMS TIGHTENED.

NEVER STORE ENGINE WITH FUEL IN THE TANK INSIDE A BUILDING. POTENTIAL SPARKS MAY BE PRESENT FOR IGNITION OF FUEL AND FUEL VAPORS.

ANY MAINTENANCE AND REPAIR ON THE ENGINE AND AUGER MUST ALWAYS BE DONE BY AN ADULT.

ENGINE MUST BE SHUT-OFF, COOL, AND SPARK PLUG WIRE REMOVED BEFORE ANY REPAIR OR MAINTENANCE CAN BE DONE.

Maintenance, replacement or repair of the emissions control devices and systems may be performed by any non-road engine repair establishment or individuals. However, items must be serviced by an authorized dealer to obtain "no charge" emissions control service.

The maintenance schedule applies to normal operating conditions. If you operate your engine under unusual conditions, such as sustained high-load or high-temperature operation, or use in unusually wet or dusty conditions, consult your servicing dealer for recommendations applicable to your individual needs and use.

TRANSPORTING YOUR EARTH AUGER

1. Never transport engine inside an enclosed space or vehicle. Fuel or fuel vapors may ignite causing serious injury or death.
2. If fuel is present in the fuel tank, transport in an open vehicle in an upright position.
3. If an enclosed vehicle must be used, remove gas into an approved red fuel container. **DO NOT siphon by mouth.**
4. Run engine to use up the fuel in the carburetor and fuel tank. Always run engine in a well ventilated area.
5. Wipe away any spilled fuel from engine and earth auger. Allow to dry.

LONG-TERM STORAGE

If your earth auger will not be used for more than one month, prepare it for long-term storage.

Follow the steps below to prepare your earth auger unit for storage. Read your engine manual for detailed instructions on preparing the engine for storage.

1. Run with gas stabilizer in fuel. The screen in the carburetor will glaze shut if gas stabilizer is not used before storage.
2. Drain the fuel system. Run the engine until it stops.
3. Change oil.
4. Remove spark plug, pour one (1) ounce of clean engine oil into spark plug hole. Cover hole with a rag. Pull starter handle slowly several times to distribute oil. Install spark plug. Do not connect spark plug wire.
5. Clean entire earth auger unit.
6. Store your earth auger unit in a clean, dry building that is inaccessible to children.

TROUBLESHOOTING AND REPAIR

At Earthquake, we build quality and durability into the design of our products; but no amount of careful design by us, and careful maintenance by you, can guarantee a repair-free life for your Earthquake powerhead. Most repairs will be minor, and easily fixed by following the suggestions in the troubleshooting guide in this manual.

The troubleshooting guide will help you pinpoint the causes of common problems and identify remedies.

For more complicated repairs, you may want to rely on your retailer, an authorized service center or Earthquake. A parts breakdown is located toward the end of this manual.

We will always be glad to answer any questions you have, or help you find suitable assistance. To order parts or inquire about warranty, call or e-mail us using the contact information found under "Ordering Replacement Parts".

CAUTION

TO AVOID INJURY OR DEATH, NEVER SIPHON FUEL BY MOUTH.

NEVER STORE EARTH AUGER WITH FUEL IN THE GAS TANK INSIDE AN ENCLOSED AREA OR BUILDING.

MAINTENANCE AND REPAIR ON THE ENGINE AND AUGER MUST ALWAYS BE DONE BY AN ADULT.

ENGINE MUST BE SHUT-OFF, COOL AND SPARK PLUG WIRE REMOVED BEFORE ANY REPAIR OR MAINTENANCE CAN BE DONE.

CAUTION

DO NOT STORE EARTH AUGER UNIT WITH FUEL IN TANK INDOORS OR IN ENCLOSED, POORLY VENTILATED AREAS, WHERE FUEL FUMES MAY REACH AN OPEN FLAME, SPARK, PILOT LIGHT OR AN IGNITED OBJECT. DRAIN FUEL OUTDOORS AWAY FROM ANY IGNITION SOURCES. USE ONLY APPROVED FUEL CONTAINERS.

FOR LONG TERM STORAGE: CLOSE FUEL SHUT-OFF VALVE AND STORE EARTH AUGER UNIT IN AN UPRIGHT POSITION. FAILURE TO DO SO CAN CAUSE OIL LEAKAGE OVER A PROLONGED PERIOD.

ORDERING REPLACEMENT PARTS

Parts can be obtained from the store where the auger was purchased or direct from the factory. To order parts visit www.getearthquake.com or call 1-800-345-6037.

For other general questions, you can e-mail us at info@ardisan.com.

IN CASE OF A SERVICE PROBLEM, DO NOT SEND EARTH AUGER UNIT BACK TO RETAILER. CONTACT EARTHQUAKE AT 800-345-6037.

Please include the following information with your order:

- 1) Part numbers
- 2) Part description
- 3) Quantity
- 4) Model number and serial number

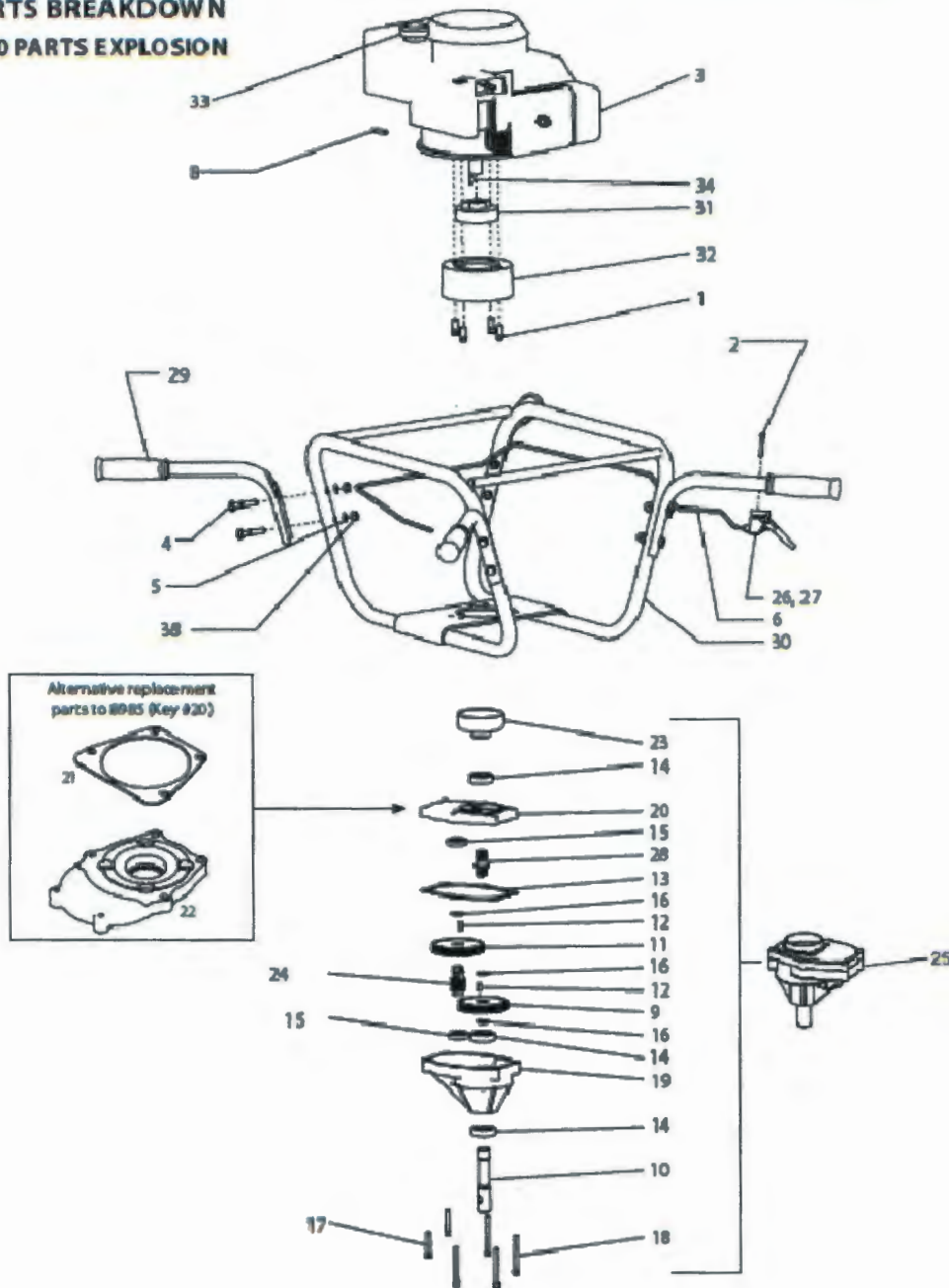
TROUBLESHOOTING GUIDE

CAUTION

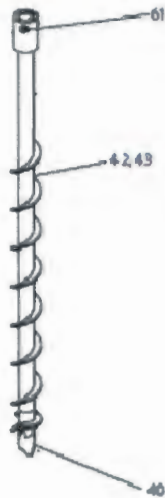
PRACTICE SAFETY AT ALL TIMES. ENGINE MUST BE TURNED OFF AND ALLOWED TO COOL, AND SPARK PLUG WIRE MUST BE DISCONNECTED BEFORE ATTEMPTING ANY MAINTENANCE OR REPAIR.

PROBLEM	POSSIBLE CAUSE	REMEDY/ACTION
Engine will not start	1. Power switch off 2. Spark plug wire disconnected	1. Flip switch to ON position 2. Connect spark plug wire to spark plug
Engine runs rough, floods during operation	1. Dirty air cleaner 2. Carburetor out of adjustment	1. Clean or replace air cleaner 2. Take to authorized Briggs & Stratton/Honda service center
Engine is hard to start	1. Stale fuel 2. Spark plug wire loose 3. Dirty carburetor	1. Drain old fuel and replace with fresh. Use gas stabilizer at end of season 2. Make sure spark wires are securely attached to spark plug 3. Clean carburetor, use gas stabilizer, new gas can
Engine misses or lacks power	1. Clogged fuel tank 2. Clogged air cleaner 3. Improper carburetor adjustment 4. Spark plug dirty, improper gap, or wrong type	1. Remove and clean 2. Clean or replace 3. Take to authorized Briggs & Stratton/Honda service center 4. Replace spark plug and adjust gap
Auger turns at idle	1. Idle speed too high 2. Broken clutch spring	1. Adjust idle speed lower 2. Replace both springs
Auger turns, but has no power	1. Carburetor out of adjustment 2. Broken transmission 3. Worn clutch shoes 4. Worn engine lower seal	1. Take to authorized Briggs & Stratton/Honda service center 2. Replace transmission 3. Replace clutch shoes and springs 4. Take to authorized Briggs & Stratton/Honda service center
Auger cuts slowly	1. Damaged point 2. Worn out blade	1. Replace tail point 2. Replace blade
Engine runs, then quits	1. Screen in carburetor plugged	1. Clean screen, use gas stabilizer, clean gas can

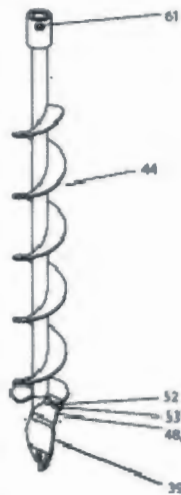
PARTS BREAKDOWN 9800 PARTS EXPLOSION



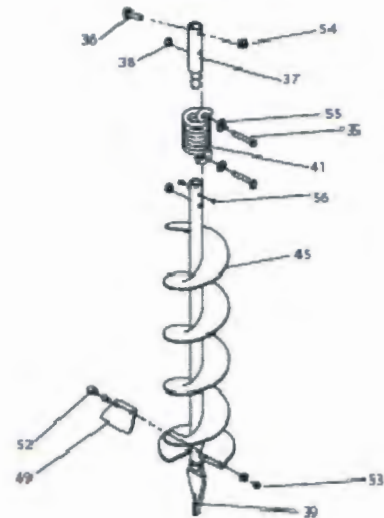
EA2F, EA3F



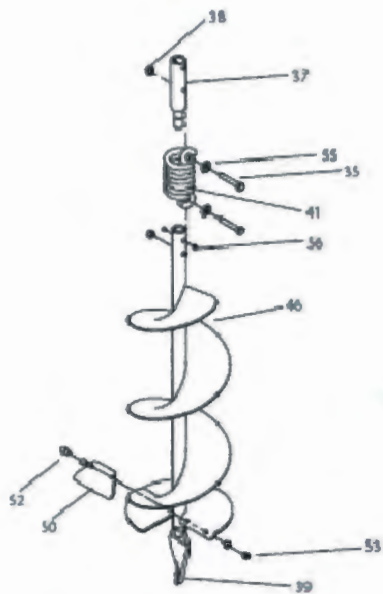
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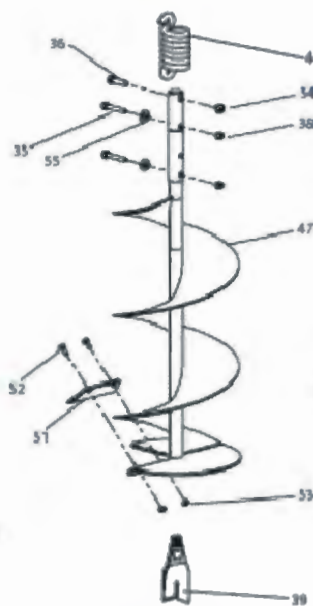
EA6F



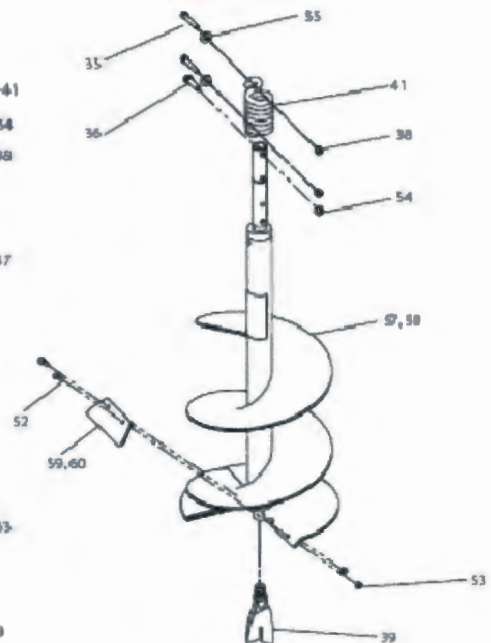
EA8F



EA10F



EA12F, EA14F



9800 PARTS LIST

KEY NO.	PART NO.	DESCRIPTION	QTY.
1	42C	BOLT, C-BORE 5/16-24 X 3/4"	6
2	4814	BOLT, PHILLIPS TRUSS HD 10-24 X 1-1/4"	1
3	513	ENGINE, BRIGGS 675 SERIES QUANTUM	1
	GC116C	ENGINE 160CC HONDA	1
4	503	BOLT, HEX HD 5/16-11 X 1-1/2"	3
5	504	LOCKWASHER, SPRING 5/16"	3
6	53627	CABLE, THROTTLE 43-1/2" (9800B only)	1
	9805A	CABLE, THROTTLE (9800H only)	1
7	—	"	"
8	63124	SPRING, THROTTLE EXTENSION	1
9	8912	GEAR, 44T 3/4" HOLE	1
10	8913	SHAFT, CUTTER 7/8"	1
11	8914	GEAR, 48T HARD	1
12	8915	DOWEL PIN, STEEL 1A" X 1/2"	2
13	8919	GASKET, POWERHEAD TRANSMISSION	1
14	8922	BEARING, BALL R12 DOUBLE LIP	3
15	8923	BEARING, BALL R10	2
16	8924	RING, SNAP EXTERNAL 3/4"	3
17	8929	BOLT, SHCS 1/4-20 X 1-1/2" (gear case bottom to gear case top)	2
18	8935	BOLT, SHCS 1/4-20 X 2-1/2" (gear case to handlebar plate)	4
19	8939	GEAR CASE, LOWER HALF	1
20	8945	GEAR CASE, UPPER HALF	1
21	*3004149	SHIM, 9800 TRANSMISSION TOP	1
22	*3004111	GEAR CASE TOP 3343/51.7/71 CC-IP ENGINES	1
23	9019	CLUTCH DRUM	1
24	9214A	GEAR, 1CT CLUSTER PINION HIT	1
25	9802B TRN PKT	TRANSMISSION ASSEMBLY 30:1 (9800B only)	1
	98005	TRANSMISSION ASSEMBLY 30:1 (9800H only)	
26	9801	RIGGER ASSEMBLY, LONG THROW (For 9800B only - includes throttle cable)	1
	9805	RIGGER ASSEMBLY, SHORT THROW (For 9800H only - includes throttle cable)	1
27	4819	RIGGER ASSEMBLY, LONG THROW (with- out cable, for 9800B only)	"
	9807	RIGGER ASSEMBLY, SHORT THROW (without cable, for 9800H only)	1
28	9816	GEAR, 27 PINION THREADED	1
29	9827	HANDLE 3-HOLES W/GRIP	4
30	9819	MAIN HANDLEBAR ASSEMBLY	1

*PART #53004149 AND 3004111 ARE REPLACEMENT PARTS AVAILABLE FOR PART # 8985.

KEY NO.	PART NO.	DESCRIPTION	QTY.
31	9825	ROTOR, CENTRIFUGAL CLUTCH COMPLETE	1
32	9837A	MCOUNT RING	1
33	9842	GAS CAP	1
34	WKG	WOODRUFF KEY #6	1
35	1423	BOLT-HCS, 5/16-18 X 2, GRADES (auger shock spring)	2
36	1433	BOLT-HCS 3/8-16 X 1-1/2" (auger to powerhead)	2
37	53684	SHOCK TOP 1-PC (used on 6" and 8" earth augers)	1
38	6456	NUT, HEX 2-WAY REVERSIBLE LOCKNUT, 5/16-18	2
39	8958-D	FISHTAIL POINT (used on 4" or larger earth auger)	1
40	8970	EARTH POINT (used on 2" & 3" earth auger)	1
41	8980	SHOCK SPRING (used on 4" and larger earth augers)	1
42	EA2F	EARTH AUGER, 2" W/FISHTAIL POINT	1
43	EA3F	EARTH AUGER, 3" W/FISHTAIL POINT	1
44	EA4F	EARTH AUGER, 4" W/FISHTAIL POINT	1
45	EA6F	EARTH AUGER, 6" W/FISHTAIL POINT	1
46	EA8F	EARTH AUGER, 8" W/FISHTAIL POINT	1
47	EA10F	EARTH AUGER, 10" W/FISHTAIL POINT	1
48	EB4	EARTH BLADE, 4" (includes EBOLT & ENUT)	1
49	EB6	EARTH BLADE, 6" (includes EBOLT & ENUT)	1
50	EB8	EARTH BLADE, 8" (includes EBOLT & ENUT)	1
51	EB10	EARTH BLADE, 10" (includes EBOLT & ENUT)	1
52	EBOLT	BOLT+HEX, 1/4-28 X 5/8", GRADE 5 (earth blade to auger)	2
53	ENUT	NUT-NYLOC, 1/4-28	2
54	2" 04	NUT, HEX LOCKING, 3/8"-6	2
55	WF516	WASHER-FLAT, 5/16"	2
56	7" 5	SETSCREW 1/4-20 X 1/4 SCPC BLK COILDED	2
57	EA12F	EARTH AUGER, 12" W/FISHTAIL POINT	1
58	EA14F	EARTH AUGER, 14" W/FISHTAIL POINT	1
59	EB12	EARTH BLADE, 12" (includes EBOLT & ENUT)	1
60	EB14	EARTH BLADE, 14" (includes EBOLT & ENUT)	1
61	8955	BOLT 3/8-16 X 1 1/4 SHCS	1
ITEMS NOT SHOWN			
—	EXT12	DEPTH EXTENSION, 12"	1
—	EXT18	DEPTH EXTENSION, 18"	1
—	EB6HD	HEAVY DUTY EARTH BLADE, 6" (includes EBOLT & ENUT)	1
—	EB8HD	HEAVY DUTY EARTH BLADE, 8" (includes EBOLT & ENUT)	1
—	EB10HD	HEAVY DUTY EARTH BLADE, 10" (includes EBOLT & ENUT)	1
—	9817	SWITCH, ON/OFF (not shown)	1

Earthquake®**9800 SERIES EARTH AUGER POWERHEAD****Warranty Terms and Conditions****PRODUCT WARRANTY: 1-YEAR LIMITED WARRANTY**

Ardisam, Inc., a manufacturing company, warrants this **EARTHQUAKE® EARTH AUGER POWERHEAD** to be free from defects in the material or workmanship for a period of one year from the date of purchase. During the one-year warranty of this product, Ardisam will furnish, at their discretion, parts and labor to correct any defect caused by faulty material or workmanship. Any unit used in a commercial application is covered for a period of 90 days after purchase. This warranty applies to the original owner with a proof of purchase and is not transferable. This guarantee is void unless the warranty card is properly filled out and received by Ardisam within 30 days of purchase or go to www.GetEarthquake.com for online registration.

For replacement parts, phone 800-345-6007 or go online to www.GetEarthquake.com.

*These warranties apply only to products which have not been subjected to negligent use, misuse, alteration, accident, unauthorized parts, failure to use proper fuel and oil, or if repairs have been performed at non-authorized service centers. These warranties supersede all other warranties either expressed or implied and all other obligations or liabilities on our part. Ardisam, does not assume, and does not authorize any other person to assume for us, any liability in connection with the sale of our products. To be a "No Charge" warranty work must be sent directly to Ardisam or one of our authorized service centers and performed by them. To obtain warranty service and/or replacement instructions, contact our customer service department at: 800-345-6007 Monday through Friday from 8 a.m. to 5 p.m. or visit www.getearthquake.com. If you choose to ship your product to Ardisam for warranty repair, you must first have prior approval from Ardisam by calling our customer service department at 800-345-6007 for a return material authorization number (RMA#). Under these circumstances, all items must be shipped prepaid. Ardisam will at no charge, repair or replace, at their discretion, any defective part which falls under the conditions stated above. Ardisam retains the right to change models, specifications and price without notice.



Earthquake™, Division of Ardisam, Inc.
1160 8th Avenue, PO Box 666
Cumberland, WI 54829
800-345-6007 | Fax 715-822-2223
E-mail: info@ardisam.com

All weights, specifications and features are approximate and are subject to change without notice. Due to continuous product improvements, product images may not be exact. Items used for props not included. Some assembly may be required.

Check for parts online at www.getearthquake.com or call 800-345-6007 M-F 8-5

APPENDIX D

OPERATIONS MANUAL FOR MASTER MFG 15 GALLON SPOT SPRAYER



123 Industrial Loop Road
Payneville, MN 56362
Phone: 1-800-864-1649
www.master-mfg.com



MASTER
MANUFACTURING

SPOT SPRAYER



INTRODUCTION

Your sprayer has been manufactured to provide the maximum in dependable efficient use. Proper operation and maintenance will ensure long satisfactory service. Study this manual carefully to become familiar with the operation and maintenance instructions.

Keep your manual in a safe, convenient place for future reference. Always mention the model and part number in any correspondence. To insure correct parts service be sure to use the part number and description when ordering.

ASSEMBLY

Check inside tank for any foreign objects. Install gun clips using screws. Attach hose to the discharge port of the diaphragm pump using plastic clamp provided. Install drain cap and washer. Install tank lid tether.

OPERATION

Operating power is obtained directly from a 12 VDC source. Be sure to connect the red to the positive (+) source and attach the black to the negative (-) source.

IMPORTANT: Before spraying chemicals, fill the tank half full of plain water to allow familiarization with the sprayer and to prevent waste of expensive chemicals.

SPRAYER MAINTENANCE

A sprayer is a carefully designed and built machine that should provide many years of reliable service if properly cared for. The main rule in caring for any sprayer is: **KEEP IT CLEAN.** Neglect costs dollars in repairs, wasted spray material and premature replacement of the sprayer.

CLEANING & STORAGE

Most spray materials are highly corrosive. The most important aspect of long dependable service from the sprayer is a thorough cleaning immediately following each use. In addition, the residue of one type of chemical could cause an undesirable effect when a different chemical is used for a different purpose.

The most effective cleaning method is to pump several rinses of clean water through the tank, pump, hoses, boom, spray gun, etc. A neutralizing agent such as a solution of Nutra-Sol, a detergent or household ammonia as recommended by the chemical manufacturer can assist in removal of a persistent chemical. When the system is thoroughly cleaned drain the tank, suction line, pump, hoses, etc.

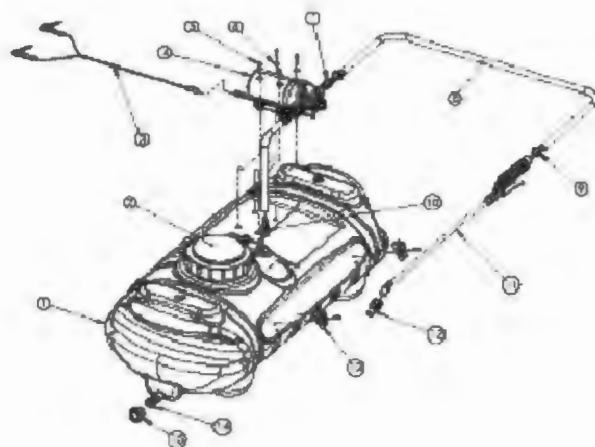
The following steps should be followed for the maintenance and storage of your sprayer:

1. Wash and flush out sprayer after completion of each phase of your program. Flush out sprayer when changing chemicals if there is a possibility of the chemicals being incompatible. Use of a detergent is advisable if the chemical manufacturer does not make specific cleaning recommendations. Flush system completely, including nozzles. Never use metal objects to open clogged nozzles.
2. Clean sprayer thoroughly before storing at the end of the spraying season. Permanent type anti-freeze added to the final rinse will leave a rust inhibiting film in parts of the sprayer.

WARRANTY

Products sold shall be warranted from defects in workmanship and material when used within the service and scope for which they were designed for a period of one year from date of purchase. Contact your distributor/ dealer for replacements parts or warranty work. Please have your original sales receipt or other proof of purchase date when requesting any warranty work.

To ensure the correct parts are acquired always provide the model number of your sprayer/attachment and the part number and description obtained from illustrated parts breakdown in this manual.



**Master Manufacturing
15/25 Gallon Spot Sprayer
Parts List**

Ref	Qty	Part No.	Description
1	1	33-10323 1	Tank, 15 gallon
	1	33-103230	Tank, 25 gallon
2	1	TL-6B	Lid, Tank
3	1	33-103234	Harness, Wire, SS.
4	1	33-103229	Pump, Shurflo, 1GPM, 15 gallon
	1	33-103232	Pump, Shurflo, 1.8gpm, 25 gallon
	1	33-103208	Pump, Delavan, 1 GPM, 15 gallon
	1	33-103209	Pump, Delavan, 2 GPM, 25 gallon
5	4	33-103126	Screw, Machine, 10-24 x 5/8, 15 gal
	4	33-103127	Screw, Machine, 10-24 x 1", 1.8 & 2.0 GPM pumps
6	4	33-103131	Washer #10, 1.8 & 2.0 GPM pumps only
7	2	A38	Fitting, 3/8"MNPT x 3/8"HB. 1.8 & 2.0 GPM pumps
8	15 ft	3204-1407	Hose, rubber, 3/8"
9	3	SHC-F	Clamp, hose
10	1	33-103121	Strainer, Inlet
11	1	SG-4507F	Wand, with filter
12	1	SG-45ASSY-18	Nozzle, Assembly
13	1	GC-100-KIT	Clip, Gun (Pair)
14	1	W406-V	Washer, Garden Hose
15	1	3N34	Cap, Garden Hose
	18"	3204-1407	Hose, rubber, 3/8" X 18" Inlet to pump
	1	SS-MANUAL-MM	Manual, (not shown)