Innovation of PT5 walk-behind trencher

April 28, 2011

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1. Team Purpose

1.1 Mission Statement

Ground Breakers is devoted to exceeding our client's expectations within the marketing, design and profitability aspects of our resourceful products. Our intent is to provide a product promoting the company's growth and development within the competitive marketplace.

1.2 Problem Statement

Our objective is to market, design and produce a PT5 Walk-behind Trencher with design specifications provided by The Charles Machine Works Inc. that serves a specific audience within a profitable business plan.

2. Statement of Work

2.1 Statement of Work

The Charles Machine Works Inc. (Ditch Witch) of Perry, Okla., requested a design for a small walk-behind trencher with the following specifications: weight of 180 to 200 pounds; small engine size (around 5hp); maximum trenching depth of 20 inches with variable depths; and maximum trenching width of 3 inches. In addition, Ditch Witch would like to spend no more than $1,750 in production costs, in order to market the product between $2,000 and $2,500.

Comparing the potential prototype to key competitors, the small trencher will be targeted towards rental yards, in addition to construction and landscaping businesses. The prototype could be used by the construction and landscaping industries for preparing areas for electrical (TV and Internet) cables, in addition to sprinkler/small irrigation systems intended for homeowners. This product has the potential to be marketed through major home improvements stores, such as Home Depot or Lowe's – targeting homeowners with similar projects of installing fencing and irrigation.

2.2 Location of Work

Research, design and product development design took place in the Biosystems and Agricultural Engineering computer lab at Oklahoma State University in Stillwater, Okla. Ditch Witch fabricated the digging teeth and frame at their headquarters in Perry, Okla. The

construction of the prototype took place in the Biosystems and Agricultural Engineering lab. Additional product testing will take place at Cowboy Motorsports, located at Lakeview and Western in Stillwater, Okla.

2.3 Period of Performance

In fall 2010 we set the following as completion goals: Dec. 9, 2010, Ground Breakers will present preliminary designs and marketing strategies for constructing a PT5 Walk-behind Trencher. Beginning in January 2011 our group will gather/purchase/fabricating materials to begin the construction of the prototype. We are setting March 11, 2011, as our construction deadline. We are planning to compete product testing and revisions by April 1, 2011. This will allow for marketing and campaign strategies to be completed for final presentations April 28, 2011.

2.4 Deliverable Schedule

The following deadlines we must meet and complete in order for our group to be successful:

Ground Breakers Deliverable Schedule		
Date	**Task**	**Deliver to**
Nov. 1, 2010	Preliminary sketches Work Breakdown Structure	Team Instructors
Nov. 5, 2010	Marketing meeting with Matt Collins at Ditch Witch Return Groundhog T-4	Ditch Witch Ditch Witch
Nov. 15, 2010	Proposal Report – 1st draft	Instructors
Dec. 9-10, 2010	Fall Presentations	Instructors/DW
Dec. 13, 2010	Self, peer & class evaluations Group Web page due	Instructors Instructors
Dec. 17, 2010 (nlt)	Deliver list of materials to client	Ditch Witch
March 11, 2011	Construction/building prototype	Team/Ditch Witch
April 1, 2011	Complete testing, repairs & revisions Begin marketing and campaign strategies/tactics	Team/Ditch Witch Team
April 29, 2011	Final Presentations	
May 6, 2011	Deliver prototype	Ditch Witch

2.5 Special Requirements

Ground Breakers traveled to Perry, Okla., to visit Ditch Witch to retrieve parts and communications materials during February – April. A list of materials was provided on Feb. 4 to ensure all components were delivered in a timely manner.

3. Task List

3.1 Product Development

- Initial research **(Before Oct. 22, 2010 - completed)**
  - Ditch Witch's purpose, products and resources

- Industry and market size
- Competitors' purpose, product, resources, business plans and campaigning strategies
  - Product test top competing products to identify competing products' advantages/disadvantages
- Dealers and suppliers
- Patents
- Technical characteristics
- Safety issues

- Business plan **(Nov. 2-14, 2010)**
  - Develop budget **(Nov. 8-14, 2010)**
  - Marketing strategies **(Nov. 2-8, 2010)**
  - Campaigning tactics **(Nov. 2-8, 2010)**

3.2 Design/Construction

- Review initial research and notes **(Oct. 22 – Nov. 14, 2010)**
- Sketch possible mini-trencher prototype(s) in Solid Works **(Oct. 22 – Nov. 14, 2010)**
- Develop list of materials and provide to client
- Build and construct mini-trencher prototype **(Beginning in January 2011)**

3.3 Testing/Evaluation

- Test prototype for product durability, reliability, maintenance needs and safety issues **(March 11 – April 1, 2011)**
- Evaluate prototype through product testing **(March 11 – April 1, 2011)**
- Adjust/repair prototype to fix any problems or improvements identified during product testing **(March 11 – April 1, 2011)**
- Finalize construction **(By April 1, 2011)**
- Retest, evaluate and improve as needed

3.4 Market product

- Rough draft of Owner's manual for prototype
- Tool Kits (Trade Show kits) – Dealers **(March – April 20, 2010)**
  - Spec Sheets

- PowerPoint (Talking points for dealers) w/ competitor info
- Advantages

- Trade Show Media Kits **(March – April 20, 2010)**
  - High resolution photos
  - Press release
- Create advertisements for primary trade publications **(April 2011)**
- Video

4. Market Research

4.1 Demographic characteristics of audience

Although Ground Breakers' goal was to make the PT5 Walk-behind Trencher accessible and usable for anyone, we narrowed Ditch Witch's audience to males between the ages of 25 and 55 – regardless of industry. In verbal communication with Matt Collins and Jeff Smith of Ditch Witch on Nov. 5, 2010, the demographics of the audience we identified is synchronized with the demographics they plan to target in their marketing efforts.

4.2 Industry performance

The following analysis of three key industries targeted includes economic status, general characteristics, psychographic characteristics, and industry size and growth. Supporting industry reports can be found in Appendix C.

Rental Yards

According to the IBIS World Industry Report, "Tools, Equipment and Other Rental Centers in the U.S.," the rental industry has seen a 4.7 percent decline since 2005, falling to $4.42 billion in revenue. However, IBIS World Reports predict the industry revenue to improve by 2015, rising to an average annual rate of 8.2 percent and $6.56 billion. As of October 2010, the rental industry has 7,515 contributing businesses. Positive predictions of the U.S. real estate market encourage economic growth in residential, industrial and commercial construction industries. Although industry reports provide evidence that residential construction is currently "hindered by poor development conditions," (Andrews, October 2010, p. 5), "the value of the industry includes new

construction and renovations of single- and multi-family homes" (Andrews, October 2010, p. 5). A significant share of the industry originates from leasing equipment to homeowners, landscapers and contractors.

According to Jeff Smith, Ditch Witch design team manager, rental yards receive more return on investment within one year of purchase, receive profit in the second year of ownership, and liquidate the used equipment during the third year of ownership. Furthermore, rental yards lease equipment to contractors expecting to receive greater returns on investment in managing equipment — rather than building with it. In addition, Smith said rental yards receive depreciation tax deductions. Therefore, these reasons motivate rental yards to offer highly rentable products for the specified geographic region.

Large rental firms in the U.S. have managed the five-year (2005-2010) decrease by diversifying their product-line – offering a wider range of equipment and services. Since Ditch Witch is a medium-sized supplier, offering another product to a wider audience is in the company's economic favor.

New Construction (Residential)

According to the IBIS World Industry Report, "Single-Family Home Building in the U.S.," about 327,320 businesses contribute to the single-home construction industry revenue of $168.5 billion. Since 2005, the industry has seen a 20.4 percent decline. However, the 2010-2015 annual growth rate is projected to increase by 16.5 percent to $361.57 billion. In 2011 alone, the industry is expecting an 11.4 percent increase in revenue growth. Although real estate values, housing demand and financing activity are estimated to improve, IBIS World does not project the industry revenue to peak above the 2005, $526.63 billion mark in the near future.

According to IBIS World, "the number of households increases with strong economic conditions, as individuals increase living expenses, disposable income and consumer confidence." (Andrews, August 2010, p. 6). As disposable income fluctuates, the demand for industry services reflects that inconsistency. Unemployment is also a key contributor in industry performance. Therefore, additional spending on renovations and personal projects are preserved until economic conditions pick up. As a country, consumers, businesses and developers rely heavily on financing

for business and personal purchases. IBIS World offers the Great Recession – which technically has ended, was due to the tightening of the credit markets because the U.S. society is heavily dependent on debt. Since 2007, businesses and individuals have not had the funding available to promote growth in the real estate and construction industries.

IBIS World estimates the housing industry to begin feeling a demand for new construction homes between August 2010 and 2015. The organization also predicts industry employment and wages to increase by 11.9 percent and 13.3 percent within this time frame. The rise in consumer profitability will promote industry growth, increasing the expected number of industry enterprises to 582,634. The industries positive predictions to 2015 support economic growth and the development of small trencher to compete in the market.

Landscaping (Designing and planning)

According to the IBIS World Industry Report, "Landscape Design and Planning Services in the U.S.," the landscaping industry had a 2.1 percent decrease in revenue since 2005. Like many other industries currently, reduced annual income has forced companies to cut employees and wages. Although, IBIS World reports the landscaping industry reacts to the construction industry's economic status. Since the construction industry saw a 20.4 percent decline, the demand for landscaping services obviously decreased. However, although most industries have seen a drastic decrease in economic growth, it is apparent the landscaping industry has seen a much smaller strain in cutting costs – especially, compared to the construction and real estate industries.

Approximately 84.7 percent of landscape design businesses are small players or sole proprietors and produce 18.8 percent of the industry revenue. With 35,832 businesses in the industry, IBIS World predicts the landscaping industry to increase by 5.1 percent or $7.5 billion by 2015 since demands for landscape design are expected to increase.

4.3 Current and potential market size

In conducting research to rent potential competing products, we found nationwide and local rental yards in Oklahoma only carried a limited number of PT5 Walk-behind Trenchers. Most rental yards contacted did not offer two competing products. After contacting 15 rental yards in Oklahoma, only ABC Equipment Rental of Tulsa, Okla., carried a Ground Hog T-4. ABC Equipment

Rental quoted Ground Breakers $150 rental fee per day, $9.50 environmental fee, $18 damage waiver fee, and $200 refundable deposit. However, most Home Depot locations in Oklahoma City and Tulsa carried a Groundsaw EZ-1900. The rental rate for the Groundsaw EX-1900 was $60 for 12 hours and $85 for 24 hours. In addition, many rental yards and home improvement stores (Home Depot) advertised online the availability of the Ground Hog T-4 or the Vermeer RT60, but did not actually have the product available for rental usage in Oklahoma. Many times, their employees did not have knowledge of these products. Currently, we have yet to locate a Vermeer RT60 in Oklahoma Rental Yards. According to Richard Sharp, Mike Buck and Jeff Smith, on Sept. 29, 2010, competing PT5 Walk-behind Trenchers may not have the capability to perform in Oklahoma soils and designing a prototype suitable for Oklahoma soils has increased potential to serve other comparable geographic regions – expanding our geographic area.

4.4 Market research

Before designing a prototype for Ditch Witch, Ground Breakers set a goal to product test competing small trenchers. However, Ground Breakers was only able to locate one competing trencher, due to availability at Oklahoma rental yards.

On Oct. 25, 2010, Ground Breakers tested a Ground Hog T-4, a top competing trencher, received from Ditch Witch at no cost. The product testing demonstrated product performance and assisted Ground Breakers in designing the prototype for Ditch Witch

Another aspect to include when marketing the new prototype trencher is mode of transportation. Since the trencher will be less than 200 pounds (which is light enough for two to three people to lift), Ditch Witch specified the need for an alternative approach for customers to transport the product. Ground Hog offers a transportation device for the Ground Hog T-4 to hook on a receiver hitch, which can be hauled with SUV-like vehicles. Although we have minimal research completed in this area, we feel a comparable design is in Ditch Witch's favor to offer in conjunction with the small trencher. However, Ground Breakers is not responsible and does not guarantee a design of a transportation/receiver hitch prototype to include in the project.

4.5 Applicable standards and regulations

Heavy Construction Equipment Rental & Leasing

According to the IBIS World Industry Report, "Heavy Construction Equipment Rental & Leasing," OSHA regulations requiring all equipment to be continually monitored, modified, and adjusted to comply and meet any changes in standard and regulations for its use in operation. According to IBIS World, OSHA has the support of the United States Standards regulations. If rental businesses fail to give sufficient or adequate information on safe use to custom hires before renting the equipment they are liable under the liability regulations.

Land Development in the US

"The industry operates in a highly regulated environment, as contractors must comply with a wide range of state and local laws and regulations relating to: land use zoning, treatment of waste, construction materials, density requirements, building design, and minimum elevation of properties." (Andrews, August 2010, p.31-32) This industry is heavily regulated and has many different regulations.

Single-Family Home Building in the US

"There is no national regulatory control of industry participation although state housing authorities impose varying methods of regulating the industry and participants are required to register or be licensed to undertake business within each state or district jurisdiction. Health and Safety regulations require that protective clothing and helmets be worn on site and that safe conditions are provided for the workers (e.g. scaffolding and ventilation). The Federal Occupational and Safety Health Administration (OSHA) enforce standards for the construction industry which are contained in Title 29 of the Code of Federal Regulations (CFR) Part 1926. State authorities assess and enforce this code. Currently, a broad range of codes govern activity in this industry including, general building codes, residential codes, mechanical codes, plumbing codes, electric codes, fire codes, accessibility codes, zoning codes, state codes, local codes and ordinances." (Andrews, August 2010, p. 32-33).

4.6 Acceptance Criteria/Safety information

After searching safety regulations, our most dependable source was Ditch Witch. According to our client, the following are important safety features Ground Breakers is aware in order to provide a PT5 Walk-behind Trencher.

- Kill/stop switch, safety chain guard over the chain boom
- Keep others at least six feet away
- Use personal protective equipment
- Color codes for utility markings
- Use proper tie-downs for transportation
- Provide information about 811(a service that marks where telephone, gas and other cables are buried)

4.7 Key industry gatherings

According to the Association of Equipment Manufacturers, trade shows are the best way to accomplish business-to-business marketing strategies, especially with dealers. In addition, most product research is conducted at trade shows. Ditch Witch attends 12 major industry association trade shows annually, including the Rental Industry Association, International Construction and Utility Equipment Exposition. The Rental Industry Association trade show attracts leaders serving the construction and homeowner industries. According to the International Construction and Utility Equipment Exposition, of those attending the annual exposition attracted were phone and cable utility contractors, landscaping businesses, equipment dealers, distributors and rental yards, and nine equipment manufacturers.

4.8 Key trade publications

According to Ditch Witch, the company utilizes the following key trade publications to promote product development: *Rental Management; Construction Equipment*; and *Rental Equipment Register*. Supporting research can be found in Appendix D.

Rental Management is a monthly paid publication, which is subscribed by 17,000 (7,500 American Rental Association members and 9,500 non-members) construction/industrial, general

tool/homeowner, party/special and other industry members. *Rental Management* does not provide specific demographic information.

Construction Equipment, a paid-subscription publication, circulates to 76,000 managers and construction equipment fleets. Their website, in conjunction to the publication, offers evaluations of machinery, a comprehensive directory of manufacturers, distributors and rental outlets, and a database of equipment specifications allowing individuals to compare competing models. The monthly publication provides the latest in new product information, such as; product development; product technology; and machine acquisition; disposal and maintenance. Presenting ideas and insight for equipment professionals is the main purpose of the magazine.

Rental Equipment Register reaches 21,204 entities spending $21.8 billion annually in the rental industry, providing advertisers a valuable audience to target. Through *RER*'s magazine and website, reports, product wire e-newsletters, buyer's and rate guides, industry event calendar and special reports are offered an innovation marketing scheme to reach a wide audience.

4.9 Further Market Research

Competitor Pricing Information		
Competing Products	**Production Cost**	**Retail Price**
Vermeer RT60	$3,200	$3,800
Ground Hog T-4	$2,400	$3,000

*Information gathered from Matt Collins, Ditch Witch project manager, on Nov. 18, 2010.

4.10 Management team and key people involved

The Ditch Witch management team includes Jeff Smith, design team manager; Mike Buck, mechanical designer; Richard Sharp; and Matt Collins, product manager. Additional key people include Tiffany Sewell-Howard, CEO and Ed Malzahn, founder of Ditch Witch and president of the Board of Directors.

4.11 Product line

The PT5 Walk-behind Trencher prototype will best fit in a new product line for smaller trenchers where Ditch Witch can expand with other models in the future. Ditch Witch offers three larger walk-behind trenchers. However, their current products are designed for large-scale trenching projects. The smallest walk-behind trencher Ditch Witch offers weighs 930 pounds with a trenching depth of 30 inches and width of 4 to 6 inches. To make the PT5 Walk-behind Trencher more appealing to small business owners and homeowners, Ditch Witch is planning to release a product on much smaller scale. For the PT5 Walk-behind Trencher prototype, we anticipate low maintenance and repair costs its customers, as we are trying to match our design to better incorporate parts currently carried and used in the design of other products manufactured and sold by Ditch Witch Anticipated input suppliers include Ditch Witch for manufacturing the frame and teeth; Honda for the engine; Tractor Supply Co. for the wheels; Drives, LLC., for the drive train; Dynacorp for the spring clutches; Anaheim Automation for the Planetary Gear Train; Quality Drive System for the sheave clutch; and McMaster-Carr for the remaining nuts, bolts, belt, sprockets and other parts.

4.12 Manufacturing expertise and capacity

Located on 80 acres in Perry, Okla., Ditch Witch has the manufacturing expertise and capacity which include the ability to fabricate rods and chains, in addition to assembling, painting and testing their products in their factory.

4.13 Marketing Techniques

Ditch Witch uses a website, Ditch Witch Mobile, the Underground (Ditch Witch's publication), various trade shows, dealers, sales representatives and product guarantee as the company's main marketing techniques.

4.14 Brand, Reputation and Trademarks

"Ditch Witch" was something Ed Malzahn called his compact trencher invention in 1949. As the name and logo implies, consumers developed an association of compact trenchers with Ditch Witch. Like other companies, Ditch Witch's reputation goes back to the product and customer

service. Current Ditch Witch trenchers carry the tradition of the original design consisting of "outstanding power, rugged frames, operator convenience, extraordinary durability, and lengthy list of innovative standard features." (Ditch Witch, 2010, Trenchers and Plows Web page). Ditch Witch is dedicated to providing product guarantees, customer satisfaction, appreciation and respect.

The Charles Machine Works Inc. has the following Trademarks: Ditch Witch®; CMW®; Subsite®; Jet Trac®; AutoCrowd®; Fluid Miser®; Roto Witch®; Super Witch®; Pierce Airrow®; and *The Underground*®.

4.15 Distribution/dealers

Ditch Witch has dealerships nationwide. Their dealerships and sales representatives promote distribution to rental yards and major construction landscaping companies. When contacting rental yards for product testing, most businesses did not carry light-weight trenchers. However, every business offered either the RT12 or RT10 – popular Ditch Witch models. This first-hand experience demonstrates that Ditch Witch has accomplished a positive reputation for the product, in addition to distributing their products to local and nationwide dealers.

4.16 Ditch Witch's financial condition

According to Matt Collins in a meeting on Nov. 5, 2010, Ditch Witch will be financing itself in the development of the PT5 Walk-behind Trencher. During the initial meeting with Ditch Witch, Jeff Smith, Mike Buck and Richard Sharp explained that remaining competitive in their current markets was the main reason for entering the new market with the PT5 Walk-behind Trencher. Based on this theory, Ground Breakers assume that Ditch Witch will continue to serve as a main contributor in their industry, in addition to being a reputable competitor in this new small-scale market.

According to Jeff Smith, Ditch Witch has a broad distribution within the United States and internationally. For the design and production of the PT5 Walk-behind Trencher, Ditch Witch will not be seeking finance as assistance in order to get the product to market. Therefore, Ditch Witch will be supporting themselves to enter this new market. Due to confidentiality, Ditch Witch did not

provide balance sheets, income statements and/or cash flow data for us to analyze and review. We were only provided the Pro Forma Overview for the PT5 Walk-behind Trencher – found in Appendix B. Therefore, Ground Breakers assumes Ditch Witch has a positive financial condition.

4.17 Available financing

Ditch Witch offers two financing options through Ditch Witch Financial Services. The first financing option is the Ditch Witch®Platinum Plus Card, intended for purchasing professional grade Ditch Witch parts, maintenance and service. The card promotes "enhancing businesses' buying power, opening credit lines, and tracking expenses with an easy-to-read monthly statement." (Ditch Witch, 2010, Financing Web page). With a dedicated line of credit, the card requires of no annual fee, no interest charged if the balance is paid in full monthly, minimum 25-day grace period, flexible repayment terms, and quarterly special promotions. Supporting research can be found in Appendix B.

Large equipment purchases are offered in the second financing option. Ditch Witch's experienced professionals help business buyers map their financing plan, such as monthly payments, rent-to-own, or customized leases.

4.18 Market Shares

Ditch Witch does not publish market share data since it is a privately-owned company.

5. Design Research

5.1 Scientific Literature Review

The trenchers we found similar to our conceptual ideas have many of the same specifications and features included in competitors' designs. Some characteristics on existing products include chain and rotary trenching types, shark and bullet type digging blades, trenching depth control, loading handles, and ground drive assists. Table 1 below shows specifications by each brand and model.

Table 1 Existing Product Specifications

Table 1: Competitor's Product Specifications					
Brand/Model	**Engine/HP**	**Trench Type**	**Max Depth**	**Width**	**Weight**
Vermeer RT60	Honda 5.5	Chain	12"	3"	270 lbs
E-Z Trench 9100	Honda 8	Rotary Disk	13"	2.5"	250 lbs
Kwik-Trench KT100	B&S 5.5	Direct Chain	8"	3"	430 lbs
Kwik-Trench KT2400B	Honda 8	Triple V-belt	12"	4"	216 lbs
Ground Hog T-4	Honda 5.5	Chain	12" or 18"	3" or 4"	230 lbs

Figure 1: Vermeer RT60

Photo obtained from: http://tinyurl.com/22t85ne

Figure 2: EZ Trench EZ 9100 Groundsaw

Photo obtained from: http://tinyurl.com/3ctf8t2

Figure 3: Kwik Trench KT100

Photo obtained from: http://tinyurl.com/3lxwadj

Figure 4: Kwik Trench KT2400B

Photo obtained from: http://tinyurl.com/3r4ngeb

Figure 5: Ground Hog T-4

Photo obtained from: http://tinyurl.com/2a772h6

5.2 Durability, reliability, maintenance costs, maintenance programs

The durability, reliability and maintenance aspects of this project are similar to the existing types of small trenchers and the companies producing them. Most of the companies producing small trenchers are relatively large, with many resources to provide to their products and their customers. Along with operator's manuals to show the customer how to use the machine, the companies also provide troubleshooting information by customer service representatives via phone and email. Maintenance resources are available within these existing companies to provide the customers with replacement parts.

5.3 Characteristics Technically Possible

Most of the features we found on existing products are relatively similar within their design. With the design intent of mini trenchers, many components on larger trenchers are undesirable for smaller trenchers due to size, weight and cost limitations. Simplicity of design is essential for small trenchers to support functionality, size and weight limitations. Some characteristics on larger trenchers are hydrostat drive control, axle differential lock for straight trenches, a pivot on the trencher arm for curved trenches, and electrical switches and components. All of these characteristics are technically possible. However, they will not satisfy the limitations for size, weight and cost. Characteristics technically possible would be depth control, ground-drive assist, loading handles, axle lock for transporting, emergency shutoff, small attached toolbox, soft handle grips, and tie-down hooks.

5.4 Safety Issues

Safety issues that must be addressed include, but are not limited to, a kill switch and a leveling system. Since this is a heavy piece of machinery used to cut into the ground, it has sharp moving parts that are dangerous. If the machine is operated on unlevel ground it could easily tip over, potentially causing serious harm to the user. Therefore, we need to address the issue of having a way to keep the trencher level on unlevel ground. If the trencher should begin to tip or if the user happens to fall away from the trencher a kill switch is needed, comparable to kill switches used on water-jets/wave runners.

5.5 Patent Searches

We discovered three patents relevant to our trencher. Each patent's abstract, claims, and drawing sheets can be found in the Appendix D

PN 7805864: The walk-behind trenching machine patent is relevant to our design of the small trencher prototype because it incorporates a trenching boom with an endless chain, which can be movable between an operating position and a transport position. This patent is useful since Ditch Witch wants a light-weight, easily transported small trencher prototype.

PN 6832443: The cutting chain patent, which was invented by our sponsor Ditch Witch, is a very useful and important patent. The chain is designed to more effectively and efficiently drag out soil, broken materials, and other underground materials to the surface providing a much cleaner trench, improving the trenching performance of the cutting chain. We could use this design to help make a smaller chain for the small trencher prototype.

PN 6658768: The trencher patent is relevant because it is designed to dig a curved trench and transition between excavating a straight section and curved section of trench. We could use this in the design to help widen our customer focus since not everyone needs to dig straight section trenches all the time.

5.6 Physical Testing & data collection

Physical testing and data collection included testing the Ground Hog T-4 (industry leader), which was supplied by Ditch Witch. Measuring components and understanding of its design were also analyzed. The testing components consisted of trenching at maximum depth of 12 inches. The results were satisfactory, although the trencher does not have any type of ground drive assist, which made it difficult to maneuver the trencher.

5.7 Modeling and Simulation

Three-dimensional Solid Works CAD drawings model the conceptual machine. Animated simulation of the PT 5 Walk-behind Trencher was produced using the CAD software. From a bill of materials, the frame and teeth were drafted to scale and sent to the Ditch Witch Product

Development Center for fabrication. All other parts were ordered from the respective entity and shipped to OSU Department of Biosystems and Engineering. Assembly and modifications were completed by Ground Breakers.

6. Product Specifications

6.1 Production Specifications

The Charles Machine Works Inc. (Ditch Witch) of Perry, Okla., requested a design for a small walk-behind trencher with the following specifications: weight of 180 to 200 pounds; small engine size (around 5hp); trenching depth of 21 inches and trenching width of 3 inches. There were no specifications provided on how fast the trencher must dig. In addition, Ditch Witch would like to spend no more than $1,750 in production costs, in order to market the product between $2,000 and $2,500.

7. Customer Requirements

7.1 Customer Requirements

Ditch Witch has given specifications, but no requirements for the PT5 Walk-behind Trencher. However, from meetings and personal conversations with Jeff Smith, Ground Breakers comprehends that including a ground-drive assist in our design will be more accepted than if we do not include it. In addition, online forums suggest consumers are willing to pay more a product with ground-drive assist, such as the Vermeer RT60. (Landscape Design & Installation Forum). Therefore, Ground Breakers will incorporate a ground-drive assist in our final design.

8. Design Concepts

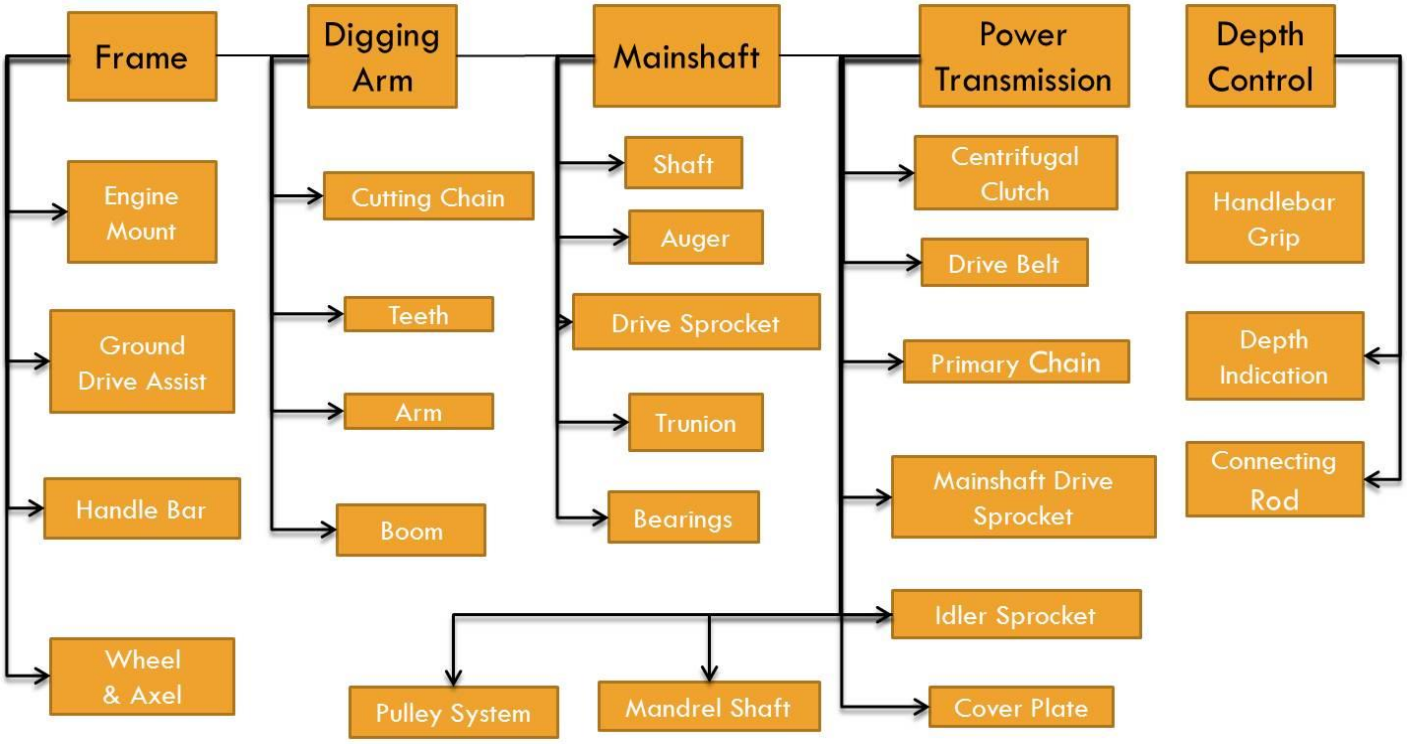
8.1 Generation of Design Concepts

Ground Breakers has generated design concepts to meet the specifications provided by our client, which offers a reliable, customer-oriented product and aesthetically marketable prototype. The process of generating design concepts consisted of research and testing of currently existing products similar to our ideological concepts. Our designs are created from existing parts and

products with an emphasis on simplicity of design, constructability and performance, while minimizing the overall weight.

8.2 Design Process

The following figure shows the main components of the trencher design, along with subcomponents. The main assemblies considered for our design were the frame, digging arm, mainshaft, power transmission, and depth control.



8.3 Design Specifications

PT5 Walk-behind Trencher Specifications		
DIMENSIONS	**U.S.**	**METRIC**
Trench depth, maximum	21 in	533 mm
Trench width	< 3 in	< 76 mm
Boom travel down: 56°		
Boom travel up: 56°		
Mainshaft height, digging chain	6 in	152 mm
Length	68 in	1.7 m
Width	20 in	508 mm
Height	40 in	1 m
Wheel width	20 in	508 mm
Wheelbase	23 in	584 mm
Centerline trench to outside edge of machine, left	15 in	381 mm
Centerline trench to outside edge of machine, right	8 in	203 mm
Spoil discharge reach	6 in	152 mm
OPERATION	**U.S.**	**METRIC**
Vehicle speeds		
Maximum transit reverse (tire)	5.8 ft/min	1.77 m/min
Digging chain speed		
6-tooth sprocket (standard)	348 rpm	
Spoils handling (single auger)		
Outer diameter	10.5 in	267 mm
Inner diameter	1.25 in	32 mm
Length	7 in	178 mm
Operating weight	225 lb	102 kg
POWER	**U.S.**	**METRIC**
Engine: Honda GS190 4-Stroke OHC		
Fuel: Gasoline		
Cooling medium: Air		
Number of cylinders: 1		
Displacement	11.4 in^3	187 cm^3
Bore	2.7 in	69 mm
Stroke	2.0 in	50 mm
Manufacturer's Power Rating Net Per (SAEJ1349)	5.2 hp	3.9 kW
Rated Speed: 3600 rpm		

PT5 Walk-behind Trencher Specifications cont.		
POWER TRAIN		
Ground drive transmission: Mechanical drive chain, controlled with one lever		
Digging chain drive: Mechanical drive chain, sheave clutch operated		
Spoils handling drive: Mechanical, attached to and rotates with headshaft		
TIRES	**U.S.**	**METRIC**
Drive		
18 x 9.5 x 8 bar lug	30 psi	207 kpa
FLUID CAPACITIES	**U.S.**	**METRIC**
Fuel tank	1.9 qts	1.8 L
Engine oil	0.61 qt	0.58 L

8.4 Design concepts

Figure 6: This figure shows the real prototype of the PT5 Walk-behind Trencher.

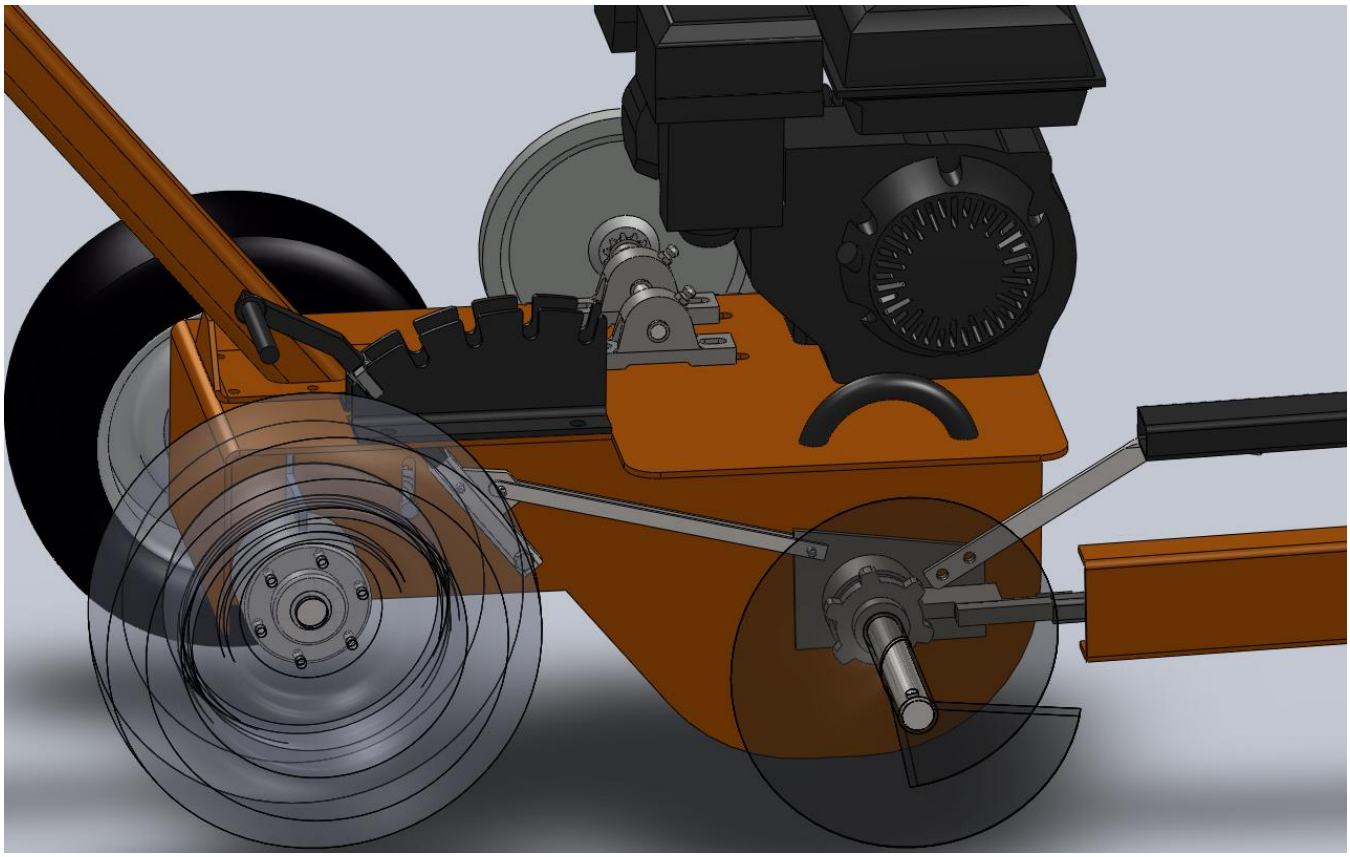


Figure 7: The figure above shows the depth control system. Five slots are available for depth position, which are at the horizontal, 4”, 10.5”, 16”, and 21”, respectively.

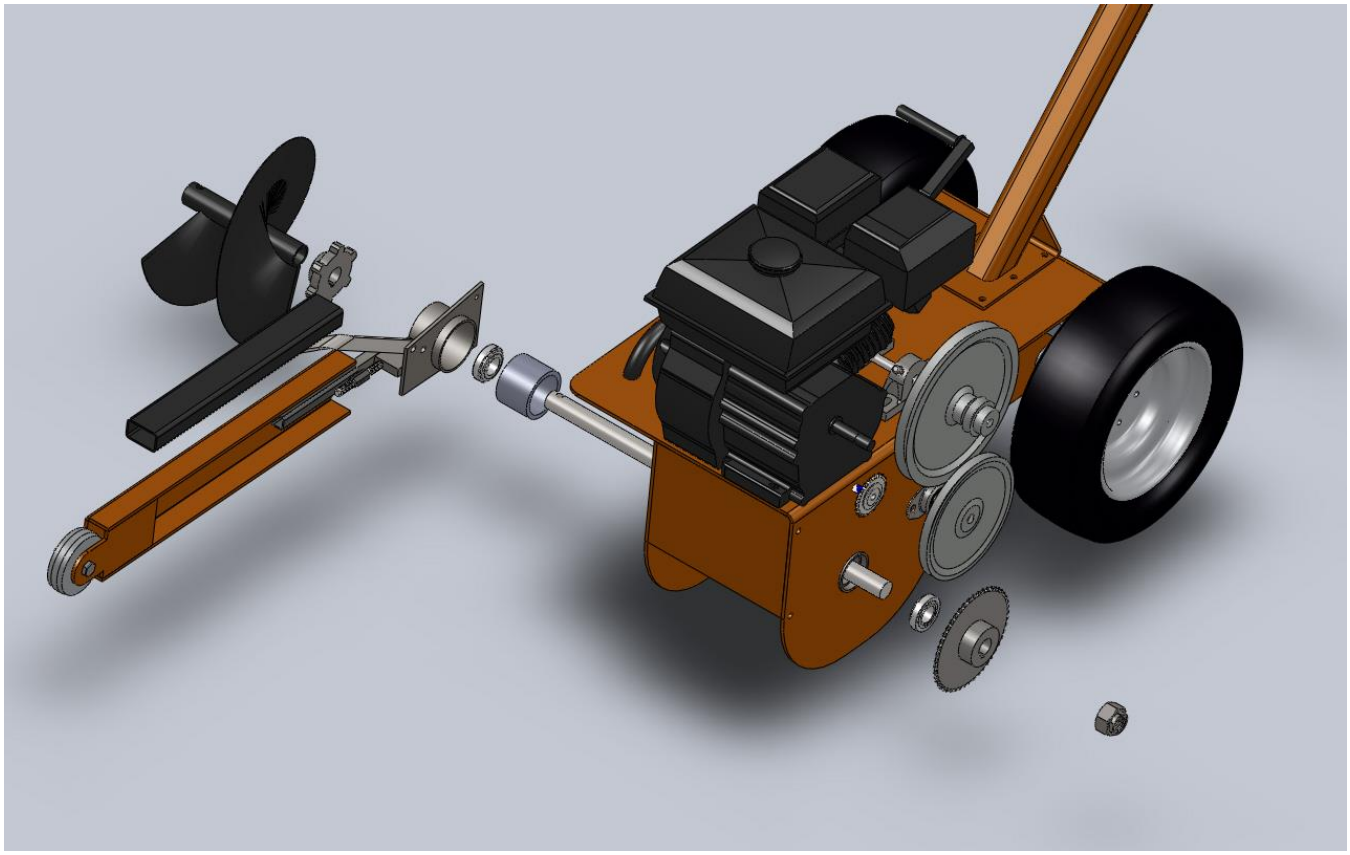


Figure 8: The figure above represents the exploded view of the main shaft of the trencher. This includes the driven sprocket, two bearings for the shaft, a bushing for depth control, the digging chain sprocket, the auger, and the digging arm assembly.

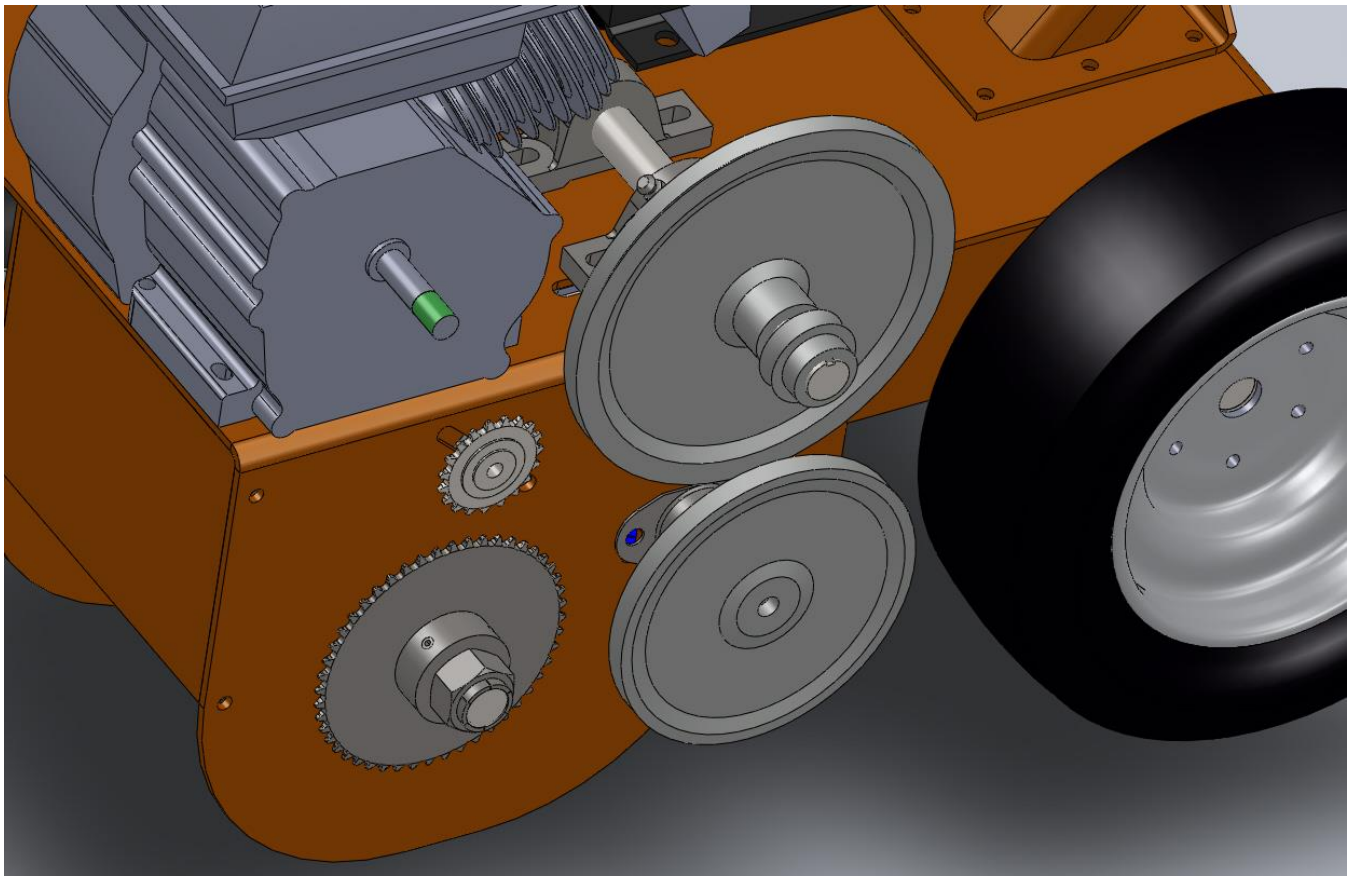


Figure 9: The figure above shows the layout for the power transmission. The mandrel shaft will be driven by a sheave/v-belt from the pto. The mandrel shaft will drive the main shaft by a chain/sprocket, as well as the input shaft for the planetary gear train for the ground-drive assist.

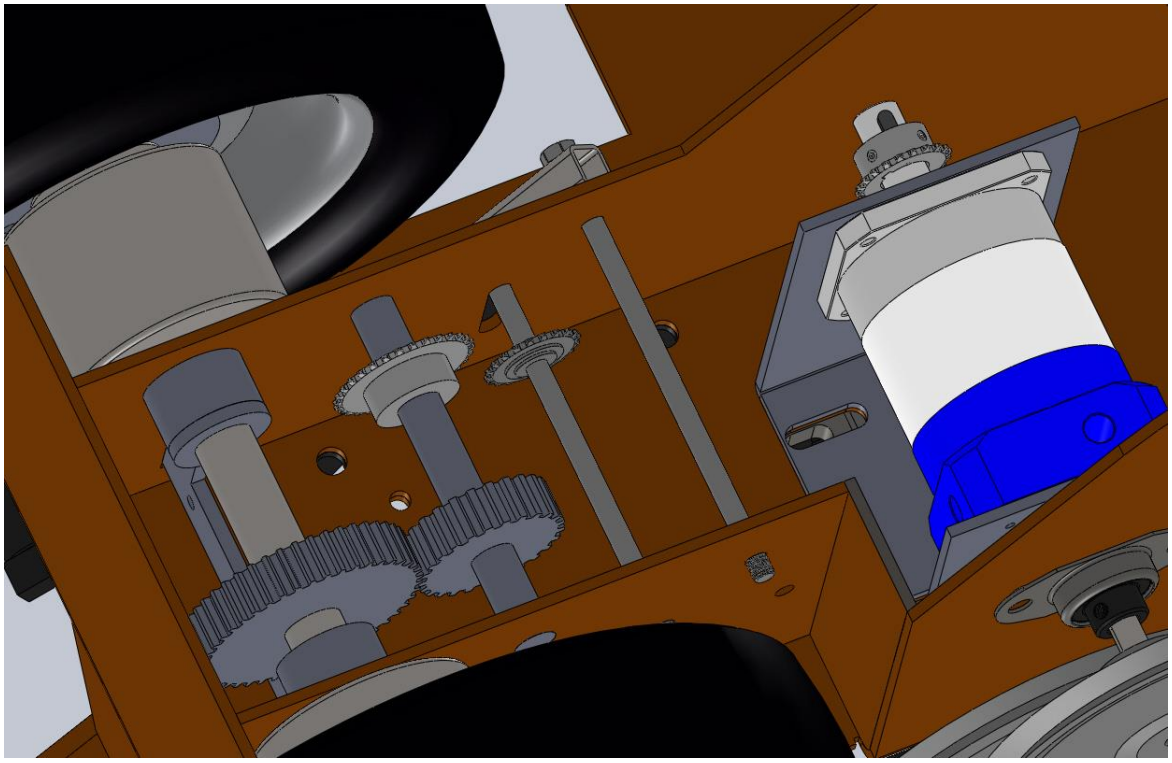


Figure 10: The figure above shows the layout of the ground-drive assist. The output from the planetary will drive the secondary shaft by a roller chain. The secondary shaft will drive the wheel shaft by a spur gear, changing the direction of rotation to reverse for trenching.

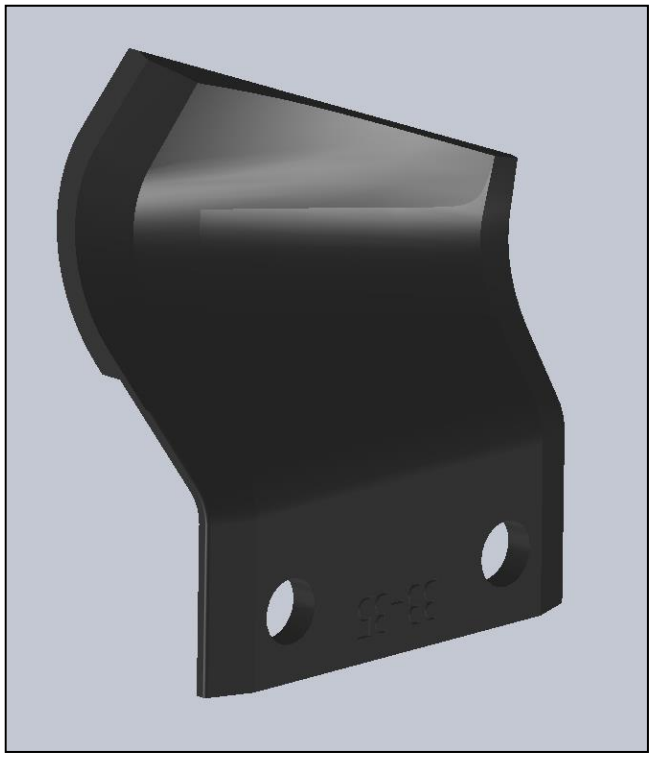


Figure 11: Digging teeth that will be attached to the chain. These teeth are used on Ditch Witch's current trenchers. The teeth are 1.75 inches tall, with 0.25" diameter holes, spaced .752" apart to mount to the chain. (Picture not to scale.)

9. Design Evaluation

9.1 Feasibility evaluation of possible designs

We have selected the Honda GS190 engine, which compared to other engine models, will provide the product with sufficient power and torque ratings for the trencher and ground-drive assist. The power transmission will consist of a mechanical friction clutch, which will engage the trencher when the rpm is increased, connected by a v-belt to a sheave with a small chain sprocket on the same shaft. The small sprocket will drive a large sprocket connected to the main shaft of the trencher.

The ground-drive assist will be powered from the power transmission as well. A planetary gear train will be used for a speed reduction for the wheel shaft. The output shaft from the

planetary gear train will have a small sprocket which will drive a sprocket on the wheel shaft. The drive assist will be controlled from the handle bar, allowing the user to engage it when needed.

The alternating teeth design is on most trenching cutting chains and is the best design for us to use in order for the teeth alignment to achieve optimum soil cutting, assuming this is the standard for all of Ditch Witch's trencher chains. The teeth will be attached to the chain to fit our specifications and design, and aligned alternating from one tooth on the left to one tooth on the right with a side bolt attachment.

The frame will be fabricated with 3/16" thick steel sheet metal, which will minimize the weight, while providing a sufficient amount of material for strength and stability. Although steel is heavier than other materials (plastics, composites, aluminum, etc.), it must be used to sufficiently support the machine's components due to its strength.

9.2 Determination of suitable designs

Determining the shaft sizes according to torque was our first step. The main shaft and mandrel shaft were calculated to be one inch in diameter. Our rpm for the chain sprocket/main shaft was desired to be ~380 rpm. For this desired speed, an overall speed reduction from the engine PTO to the mainshaft was calculated to be 9.5:1, which was met through a reduction from v-belt sheaves and a reduction from chain sprockets.

For the ground-drive assist, a desired rpm was that less than 2 rpm. For this, we have selected to use a planetary gear train to largely reduce the shaft speed using a gear ratio of 100:1. The calculated speed of the wheel shaft was calculated to be 1.7 rpm. With 13" diameter wheels, the ground speed of the trencher was calculated to be 5.8 ft/min.

The chain was figured to be a #35H (3/8" pitch) through a design process in "Design Manual for Roller and Silent Chain Drives" by Jackson and Moreland. The small sprocket has 15 teeth, while the large sprocket has 45 teeth.

The angle for our maximum trenching depth was determined to be 56 degrees from the horizontal. The depth control is divided up into five different angles. The first one is for transportation and when the digging arm is up. The second notch on the depth control is at a 20 degree angle with trenching depth of 4 inches, the third is at a 30 degree angle and trenching

depth of 10.5 inches, the fourth is at a 43 degree angle and 16 inches deep, and the last notch is at a 56 degree angle and trenches the maximum depth of 21 inches deep.

9.3. Testing and Results

We began testing on April 22, 2011, in dry soil. Our first test resulted in the mandrel shaft bending and the belt flying off. There were a few parts that we had to reorder due to damage. In order to fix the problem, we went from our initial ½ inch diameter shaft to a 1 inch diameter shaft. This change increased the strength and stability of the trencher. Our second test was conducted on April 26, 2011, in moist soil. This time the plate holding the boom and digging arm bent. We took the trencher back to the lab and welded two metal bars on both sides of the plate to reinforce it. By adding the metal bars we were able to increase the strength and durability of the digging arm. Once we completed our adjustments, we took it out for another test. This was a successful run, and we were able to trench at each depth control setting. After trenching at the settings we measured the depths to make sure they were where we wanted them. The 16 inch setting was about 15.5 inches deep, the 4, 10.5, and 21 inch settings were correct. The trench width was measured at 3 inches and the trencher trenched 0.65 inches/second (3.25 ft/min) at the 10.5 inch setting without the ground-drive assist engaged. However, we assume with the ground drive assist the trenching speed will be faster since it is calculated to move at 5.8 ft/min. During testing, we were unable to verify this calculation, due to a mistake in the initial design. The clutches are in place to keep the trencher from moving faster than it trenches. Due to time constraints we were unable to complete all of the testing needed before manufacturing. Further testing is needed including:

- Testing with the ground-drive assist
- Testing without the auger to determine if it is needed
- Testing in different soil types (sand, silt, clay) to determine what soil types are ideal for the trencher
- Testing in muddy soil to determine if it can be used in rainy seasons
- Testing in hard/frozen soil to determine if it can be used in winter

10. Project Budget

10.1 Material list and costs

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
Honda	**Honda GS190**	**Engine**	**5.2 hp, 30.4lbs**	**30.4**	**30.4**	**1**	**$ 294.00**	**$ 294.00**
Dynacorp 1-800-800-6445	**SC-8**	**Clutch**	**spring clutch; 2500 Torque (in.lbs) Max RPM 300, 1"diameter**		**0**	**2**	**$ 140.00**	**$ 280.00**
Quality Drive Systems 626-293-5770	**40026**	**Clutch**	**sheave clutch**	**2.5**	**2.5**	**1**	**$ 98.00**	**$ 98.00**
Ditch Witch		**Steel Shaft**	**42" of 1" diameter**		**0**	**1**		**$ -**
		Steel Shaft	**10" of 0.5" diameter**		**0**	**1**		**$ -**

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
		Square Tubing	10.5" of 20x20x2 iso		0	1		$ -
		Rectangular Tubing	12" of 50x30x2.6 iso		0	1		$ -
		Rectangular Tubing	35" of 2x2x0.25 ansi inch		0	1		$ -
		Sheet Metal	1100 sq. in. of Gauge 6		0	1		$ -
		Digging Teeth	Teeth		0	35		$ -
Anaheim Automation 714-992-6990	GBPH-0902-NS-100-AA341-500	Planetary Gear Train	100:1 Gear Ratio, Max input speed 6000 RPM, Rated Output Torque 23,788.8 oz-in, 3 stage	12.73	12.73	1	430.92	$ 430.92
McMaster-Carr 609-689-3415	6280K375	Roller Chain Sprocket	Steel Finished-Bore Roller Chain Sprocket for #35 Chain, 3/8" Pitch, 15 Teeth, 1" Bore (Same as 6280K117)		0	1	$ 9.65	$ 9.65

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
	273T325	Roller Chain Sprocket	Pitch: 1/4", Bore size: 1", Teeth: 48, Outside Diameter: 3.96"		0	1	$ 13.37	$ 13.37
	2737T266	Roller Chain Sprocket	Steel Finished-Bore Roller Chain Sprocket for #25 Chain, 1/4" Pitch, 36 Teeth, 1" Bore		0	1	$ 10.33	$ 10.33
	6280K322	Roller Chain Sprocket	Steel Finished-Bore Roller Chain Sprocket for #35 Chain, 3/8" Pitch, 10 Teeth, 1/2" Bore		0	1	$ 6.63	$ 6.63
	90104A010	Coupling Nut	Type 316 Stainless Steel Coupling Nut 3/8"-16 Thread Size, 1-1/8" Length, 1/2" Width		0	1	$ 3.86	$ 3.86
	6384K63	Ball Bearings	Steel Ball Bearing Plain Double Shielded for 1/2" Shaft Dia, 1-3/8" OD		0	1	$ 8.01	$ 8.01

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
	94731A360	Shoulder Screw	18-8 Stainless Steel Hex Head Shoulder Screw 1/2" Shoulder Dia, 1-5/16" Shldr L, 3/8"-16 Thread		0	1	$ 11.18	$ 11.18
	90257A063	Machine Screw Hex Nuts	Type 316 SS Machine Screw Hex Nut 3/8"-16 Thread Size, 5/8" Width, 1/4" Height		0	1	$ 6.75	$ 6.75
	7208K52	Mounted Bearings	Steel Flange-Mounted Ball Bearing for Shaft Diameter 1/2", O'all Length 3-3/4"		0	1	$ 23.02	$ 23.02
	6494K14	Mounted Bearings	Nickel-Plated Cast Iron Mounted STL Ball Brng 2-Bolt Base Muont, for 1" Shaft Diameter		0	2	$ 39.74	$ 79.48
	5709K170	Roller Bearings	Steel Tapered-Roller Bearing Roller Assembly for 1" Shaft Diameter		0	2	$ 19.26	$ 38.52

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
	2869T16	Sleeve Bearing	Grooved Bronze Flanged Sleeve Bearing for 1" Shaft Dia, 1-1/4" OD X 1" Lx1-1/2" Flange OD		0	2	$ 14.31	$ 28.62
	7265K204	Roller Chain Sprocket	Heavy ANSI Roller Chain #35H, Single Strand, 3/8" Pitch, .200" Dia, 4'L (Same as 7265K2)		0	1	$ 33.64	$ 33.64
	6280K332	Roller Chain Sprocket	Steel Finished-Bore Roller Chain Sprocket for #35 Chain, 3/8" Pitch, 11 Teeth, 1/2" Bore		0	1	$ 8.86	$ 8.86
	6663K210	Idler Sprocket	Roller Chain Idler Sprocket Steel W/Ball Brng, for #35 Chain, 19 Teeth, 3/8" Bore		0	1	$ 22.22	$ 22.22
	6245K944	9" Pulley	Die Cast V-Belt Pulley 4L, A-, & Ax Section Belt, 9" OD, 1" Bore		0	1	$ 21.40	$ 21.40

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
	6245K516	3" Pulley	Die Cast V-Belt Pulley 3L & O-Section, 3" OD, 1/2" Bore		0	1	$ 6.69	$ 6.69
	6245K541	7" Pulley	Die Cast V-Belt Pulley 4L, A-, & Ax-Section Belt, 7" OD, 1" Bore		0	1	$ 12.42	$ 12.42
	91257A563	Cap Screws	Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow-Plated, 1/4"-20 Thread, 6-1/2" Length		0	1	$ 8.35	$ 8.35
	94827A038	Lock Nut	Cadmium-Pltd STL Expanding Heavy Hex Locknut 1"-8 Thread Size, 1-1/2" Width, 1-1/64" Height		0	1	$ 10.15	$ 10.15
	92390A848	Pins	18-8 Stainless Steel Clevis Pin W/Hairpin Cotter Pin, 1/4" Diameter, 1-1/4" Length		0	3	$ 1.33	$ 4.00
	92198A650	Hex Head Cap Screws	18-8 SS Hex Head Cap Screw 3/8"-16 Thread, 7" Length		0	1	$ 2.40	$ 2.40

Vendor	Product/Order Number	Product	Product Specification	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
	92198A652	Hex Head Cap Screws	18-8 SS Hex Head Cap Screw 3/8"-16 Thread, 8" Length		0	1	$ 2.96	$ 2.96
	92415A864	Spacers and Standoffs	Zinc-Plated Steel Unthreaded Spacer 1/2" OD, 3/8" Length, 1/4" Screw Size		0	32	$ 1.47	$ 47.04
	92415A861	Spacers and Standoffs	Zinc-Plated Steel Unthreaded Spacer 1/2" OD, 3/16" Length, 1/4" Screw Size		0	32	$ 1.35	$ 43.20
Drives LLC 1-800-435-0782	2080H	Chain	Steel 57" long, 0.626" wide, with a 2" pitch		0	1	$ 120.00	$ 120.00
Tractor Supply Co.		Wheels	Turf Trac R/S		0	2	$ 20.00	$ 40.00
		Labor	6.5 hours		0	6.5	$ 10.0	$ 65.00
		Nuts/Bolts/Washers/Belts			0	1	$ 75.00	$ 75.00

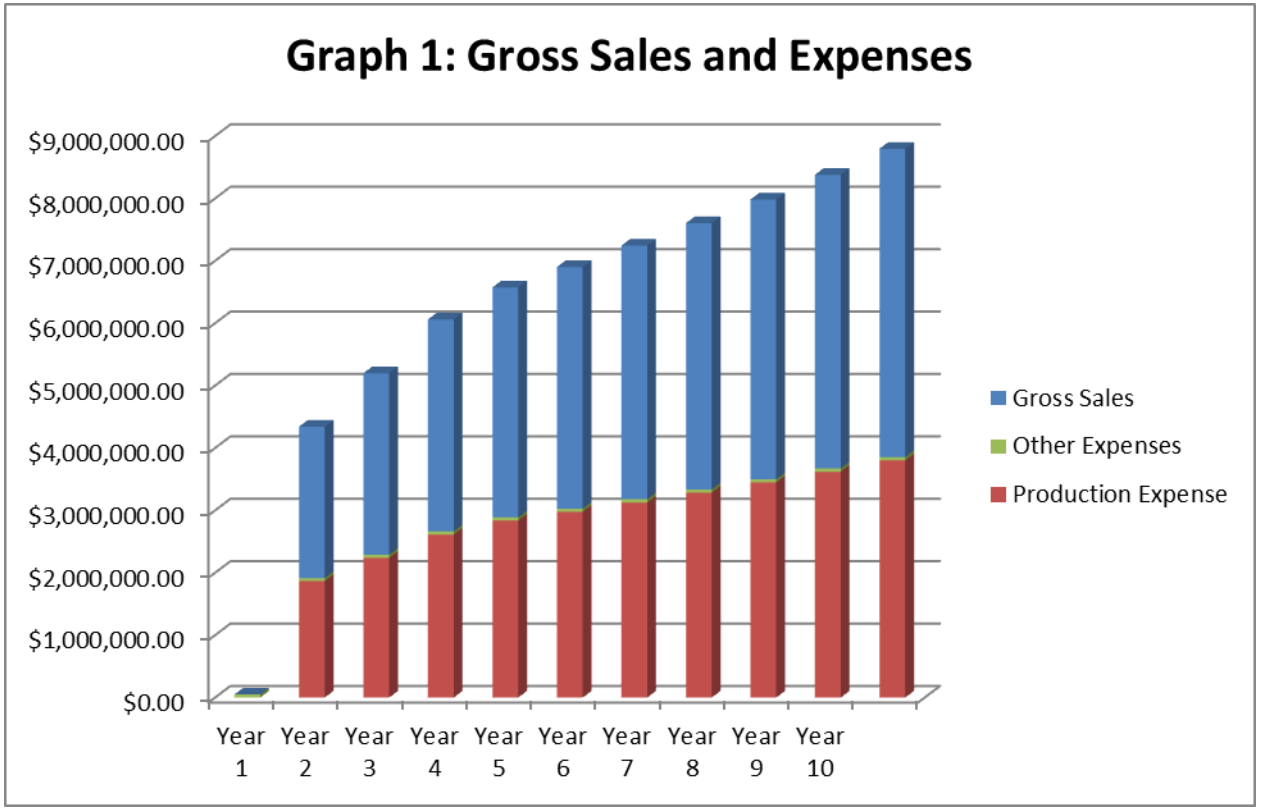
	Weight in lbs.	Total Weight in lbs.	Quant.	Price/item	Total Price
Sub-Total	45.63	45.63	148.5	$ 1,487.27	$ 1,865.67
Grand Total Cost of Product Material				**$ 1,865.67**	
Grand Total Cost of Product Material & Shipping Cost				**$ 1,865.67**	
Total Weight in Pounds				**211.31**	
Specified Cost Constraint				**$ 1,750.00**	

10.2 Market projection

Based on conversations with Ditch Witch, we assume the market potential for this new product is very high. With this new product Ditch Witch are entering a new market and will be competing with market leaders like the Vermeer and the Ground Hog. With this PT5 Walk-behind Trencher Ditch Witch will have a market advantage having a maximum depth of 21", maximum width of 3", ground-drive assist, weighs 225 pounds with a comparable cost. Our client plans to produce 1,000 units within the first year of hitting the market, and expecting to grow 20 percent the second year, approximately 17 percent in year 3, 9 percent in year 4, and then a steady growth of 5 percent until year 10. Based on these assumptions, Ditch Witch expects 15,978 units within the first 10 years. Since Ditch Witch will be manufacturing this prototype, our client will market the PT5 Walk-behind Trencher at 30 percent above total cost. Thus, the dealers can then set their own price and be able to negotiate price with the customer.

10.3 Return on Investment

Discount Rate	12.00%											
Year		0	1	2	3	4	5	6	7	8	9	10
Gross Margin			$2,425,366	$2,910,439	$3,396,540	$3,686,945	$3,871,292	$4,064,857	$4,268,099	$4,481,504	$4,705,580	$4,940,859
Discount Factor		1	0.892857143	0.797193878	0.711780248	0.635518078	0.567426856	0.506631121	0.452349215	0.403883228	0.360610025	0.321973237
PV of Income		$0	$2,165,505	$2,320,184	$2,417,590	$2,343,120	$2,196,675	$2,059,383	$1,930,671	$1,810,004	$1,696,879	$1,590,824
Total Expense		$50,000	$1,915,666	$1,915,666	$2,289,299	$2,663,728	$2,887,626	$3,029,947	$3,179,363	$3,336,229	$3,500,918	$3,673,819
Less Depreciation and Term Interest			$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cash Expenses		$50,000	$1,915,666	$1,915,666	$2,289,299	$2,663,728	$2,887,626	$3,029,947	$3,179,363	$3,336,229	$3,500,918	$3,673,819
Discount Factor		1	0.892857143	0.797193878	0.711780248	0.635518078	0.567426856	0.506631121	0.452349215	0.403883228	0.360610025	0.321973237
PV of Expenses		$50,000	$1,710,416	$1,527,157	$1,629,478	$1,692,848	$1,638,517	$1,535,065	$1,438,182	$1,347,447	$1,262,466	$1,182,871.52
Benefits Less Costs		($50,000)	$509,700	$994,773	$1,107,241	$1,023,216	$983,666	$1,034,909	$1,088,736	$1,145,275	$1,204,662	$1,267,039
PV Benefits Less PV Costs		($50,000)	$455,089	$793,027	$788,112	$650,272	$558,158	$524,317	$492,489	$462,557	$434,413	$407,953
Total PV of Income	$20,530,837											
Total PV of Expenses	$15,014,448											
Net Present Value	$5,516,389											


Graph 1: Gross Sales and Expenses
$9,000,000.00
$8,000,000.00
$7,000,000.00
$6,000,000.00
$5,000,000.00
$4,000,000.00
$3,000,000.00
$2,000,000.00
$1,000,000.00
$0.00
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
Year 8
Year 9
Year 10
Gross Sales
Other Expenses
Production Expense

11. Marketing/Campaign

11.1 Objective

Our objective is to sell 1,000 units within one year after release date to dealers in Oklahoma, Kansas, Texas, Colorado and Missouri.

11.2 Strategies

One strategy we will use to market the PT5 Walk-behind Trencher unveil the new prototype at the American Rental Association trade show, also known as The Rental Show, in New Orleans, La., Feb. 5-8, 2012. The trade show attracts rental businesses in the construction/industrial, general tool/homeowner, party/special and other event segments of the industry. According to communication with Chris Coleman, American Rental Association marketing manager, on March 28, 2011, The Rental Show does not release specific demographic information about attendees. However, based on the list of segments mentioned above, construction/industrial, general tool/homeowner, party/special and other, we can assume to target less than 25 percent of the trade show's total attendance (5,000-7,000).

11.3 Tactics

To unveil and market the product at The Rental Show, Ditch Witch will need materials to promote and sell the product to rental and distribution companies. Therefore, Ditch Witch personnel will have Tool Kits containing product literature, including specification sheets, a PowerPoint presentation to educate deals about the product, pre-designed advertisements and a product video. However, other pertaining literature Ditch Witch finds suitable could supplement the materials listed above, such as competitor information. According to Matt Collins with Ditch Witch, the tool kits are provided to dealers attending trade shows interested in distributing their products. In addition, Ditch Witch will need to submit a press kit to the trade show. Therefore, the press kits will have high and low resolution photos of the PT5 Walk-behind Trencher and press releases on new products and company development. These press kits will be offered on flash drives in the media room and at the Ditch Witch booth, which will contain press kits for all the products Ditch Witch is marketing at the trade show.

To unveil the PT5 Walk-behind Trencher at The Rental Show, Ditch Witch will need to advertise their new product in *Rental Management,* a publication owned by the American Rental Association, beginning in the February issue. The February issue of *Rental Management* focuses on exhibitors' new products at The Rental Show, which is important since we'll be unveiling the product at the show. Although there is potential for the publication to come out before the show, the February issue is intended to promote new products to be unveiled during the trade show. After unveiling the product in February, Ditch Witch will need to continue advertising in *Rental Management* since the publication has 17,000 subscribers, which in includes 7,500 American Rental Association members as subscribers. Therefore, we propose Ditch Witch to run 12 full-page, full-color ads in *Rental Management*.

In addition, we recommend Ditch Witch begin advertising in *Construction Equipment* in March. This publication reaches 76,000 managers and construction equipment fleets. The advertisement will be a half-page, full-color marketing tool.

After unveiling the PT5 Walk-behind Trencher in February 2012, we recommend Ditch Witch continue to market the new product at other trade shows, such as the International Construction Utility and Equipment Exposition, also known as The Demo Expo held in October annually.

11.4 Marketing campaign budget

Marketing campaign budget				
Tactic	**Material detail**	**Quantity**	**Price**	**Total $**
Advertising in *Rental Management*	Full-page w/ bleed; 4-color	12	$3750	$45,000
Advertising in *Construction Equipment*	Half-page; 4-color	12	$8,270	$99,240
Tool Kits	The Rental Show	500	$5	$2,500
Not included in PT5 budget (Costs for DW to cover from general accounts)				
Press Kits	Trade Show Media Kits (Flash Drives)	100	$20	$2,000

11.5 Monitoring measurement/success of tactics

To measure the success of the advertisements, each ad will contain a QR code, linked directly to the Web page of the PT5 Walk-behind Trencher on Ditch Witch's website, which will provide the amount interested in the new product. In addition, Ditch Witch will scan dealers' nametags in exchange for giving them a Tool Kit. This will offer the opportunity for Ditch Witch follow-up with the dealers through personal contact and email after the trade shows.

12. References

12.1 Conversations/Personal Communication

Coleman, Chris, American Rental Association, email communication on March 28, 2011.

Collins, Matt, Ditch Witch, telephone communication on March 31, 2011.

Lamerton, Jeri, email communication on March 6, 2011.

Lamerton, Jeri, email communication on April 4, 2011.

Smith, Jeff, Mike Buck and Richard Shaprt of Ditch Witch, business meeting/personal communication in Perry, Okla., on Sept. 29, 2010.

Smith, Jeff and Matt Collins of Ditch Witch, business meeting/personal communication in Perry, Okla., on Nov. 5, 2010.

Smith, Jeff, Mike Buck and Richard Sharp of Ditch Witch, business meeting/personal communication in Perry, Okla., Nov. 19, 2010.

12.2 Related research

Andrews, Robert J. (August 2010). IBIS*World* Industry Report 23311: Land Development in the US. Publisher: IBIS*World* Inc.

Andrews, Robert J. (August 2010). IBIS*World* Industry Report 23321: Single-Family Home Building in the US. Publisher: IBIS*World* Inc.

Andrews, Robert J. (October 2010). IBIS*World* Industry Report 53231: Tools, Equipment & Other Centers in the US. Publisher: IBIS*World* Inc.

Bolay, Brent. (Sept. 1, 2002). Selecting the Right Trencher. On Versalift East. Retrieved on Oct. 15, 2010, from http://www.versalifteast.com/articles/selectingatrencher.htm.

Culbert, Kevin. (June 2010). IBIS*World* Industry Report 54132: Landscape Design & Planning Services in US. Publisher: IBIS*World* Inc.

Wilson, Michael. (September 2010). IBIS*World* Industry Report 53241: Heavy Construction Equipment Rental & Leasing in the US. Publisher: IBIS*World* Inc.

12.3 Patents

United States. Department of Commerce. Patent and Trademark Office. *Cutting Chain.* Piel, Martin Roy, et. al. PN 6832443. Retrieved October 20, 2010. http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=6832443.PN.&OS=PN/6832443&RS=PN/6832443.

United States. Department of Commerce. Patent and Trademark Office. *Trencher*. Bainter, Wesley Allen. PN 6658768. Retrieved October 20, 2010. http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=6658768.PN.&OS=PN/6658768&RS=PN/6658768.

United States. Department of Commerce. Patent and Trademark Office. *Walk Behind Trenching Machine*. Azure, John P., et. al. PN 7805864. Retrieved October 20, 2010. http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=7805864.PN.&OS=PN/7805864&RS=PN/7805864.

12.4 Websites

(2010). About Equipment World. On Equipment World. Retrieved on Oct. 20, 2010, from http://www.equipmentworld.com/about-equipment-world.

(2010). About Landscape & Irrigation. On Landscape and Irrigation. Retrieved on Oct. 20, 2010, from http://tinyurl.com/257jdrg.

(2010). About the Magazine. On Landscaping & Groundspeeking. Retrieved on Oct. 20, 2010, from http://lg.baumpub.com/magazine/about.

(2010). About Us. On Construction Equipment. Retrieved on Oct. 19, 2010, from http://constructionequipment.com/page/about-us.

(2010). Ditch Witch Safe. On Ditch Witch. Retrieved on Oct. 20, 2010, http://ditchwitch.com/safe.

(2010). Financing. On Ditch Witch. Retrieved on Oct. 17, 2010, http://ditchwitch.com/safe/.

(2010). Financing. On Ditch Witch. Retrieved on Oct. 20, 2010, http://www.ditchwitchok.com/custompage.asp?pg=financing.

(2010). Education and Events. On American Rental Association. Retrieved on Oct. 14, 2010, from http://therentalshow.com/EducationandEvents.aspx.

(2010). Equipment World October 2010. On Equipment World. Retrieved on Oct. 19, 2010, from http://www.digitalmagazinetechnology.com/a/?KEY=equipmentworld-10-10october#page=0.

(2010). Groundhog T4 vs. Vermeer RT60. On LawnSite.com™ - Moose River Media. Retrieved on Sept. 27, 2010, from http://www.lawnsite.com/showthread.php?t=170961.

(2010). Industry Links. On Ditch Witch. Retrieved on Oct. 20, 2010, http://ditchwitch.com/resources/industry-links.

(2010). Previous Issues. On Landscape Contractor. Retrieved on Oct. 20, 2010, from http://tinyurl.com/2ebdk2r.

(2010) RT60 Mechanical Mini-Trencher. On Vermeer. Retrieved on Oct. 15 2010, from http://www2.vermeer.com/vermeer/equipment/trenchers/rt60.

(2010). T-4 Trencher. On Ground Hog Inc. Retrieved on Oct. 13, 2010, from http://www.groundhoginc.com/productview.php?iProductID=7.

(2010). Trade Shows. On Association of Equipment Manufacturers. Retrieved on Oct. 19, 2010, from http://www.aem.org/TradeShows/TradeShows/.

(2010). Trencher & Plows. On Ditch Witch. Retrieved on Sept. 17, 2010, from http://ditchwitch.com/trenchers-plows/walk-behind.

(2010). Walk-behind Trencher & Vibratory Plows. On Ditch Witch. Retrieved on Sept. 17, 2010, from http://ditchwitch.com/trenchers-plows/walk-behind.

13. Appendices

13.1 Appendix A – Ground Breakers
13.2 Appendix B – The Charles Machine Works Inc.
13.3 Appendix C – Design Research
13.4 Appendix D – Industry Research
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INNOVATION OF PT5 WALK-BEHIND TRENCHER

April 28, 2011

Ground Breakers

Lisa Brown · Elizabeth DeKinder

Robert Parrish · Chase Vencl

The Charles Machine Works Inc.

- Located in Perry, Okla.
- Commonly known for trenchers

Problem Statement

Our objective is to design, market and produce a small, walk-behind trencher with design specifications of:

Specification	Detail
Trenching depth	~20 in.
Trenching width	<3 in.
Weight	180-200 lbs.
Engine size	~5hp

Design Purposes

- Fencing
- Irrigation
- Other landscaping services
- Electrical lines
  - TV cables
  - Internet cables

Audience

- Major dealers (primary)
  - Rental yards
  - Landscaping
  - Construction
    - Potential for retail/rental in home improvement stores
      - Lowes
      - Home Depot

Competitors

- **Vermeer RT60**
- **Ground Hog T-4**
- E-Z Trench 9100
- Kwik-Trench KT100
- Kwik-Trench KT2400B

Vermeer RT60

Specification	Detail
Trenching depth	12 in.
Trenching width	3 in.
Weight	270 lbs.
Engine	Honda 5.5hp
Trench Type	Chain
Production costs	~$3,200
Retail price	$3,800

- Ground-drive assist
- Patent pending

http://tinyurl.com/22t85ne | http://tinyurl.com/29holjn

Ground Breakers

Ground Hog T-4 (market leader)

Specification	Detail
Trenching depth	12 or 18 in.
Trenching width	3 or 4 in.
Weight	230 lbs.
Engine	Honda 5.5hp
Trench Type	Chain
Production costs	~$2,400
Retail price	$3,000

http://tinyurl.com/2a772h6 | http://tinyurl.com/2g4qnqz

Ground Breakers

Design Key Features

- **Ground-drive assist**
- Maximum operating depth at 21"
- <3"trench width
- Minimize Weight
- Fit in the bed of a truck
- Emergency shut off of chain/engine
  - operator releases handle bar
- Minimize cost

Design

Design

Ground Breakers

Design specifications

DIMENSIONS	U.S.	METRIC
Trench depth, maximum	21 in	533 mm
Trench depth, position 2	4 in	102 mm
Trench depth, position 3	10.5 in	267 mm
Trench depth, position 4	16 in	406 mm
Trench depth, position 5	21 in	533 mm
Trench width	3 in	76 mm
Boom travel down: 56°		
Boom travel up: 56°		
Mainshaft height, digging chain	7.3 in	185 mm
Length	68 in	1.7 m
Width	20 in	508 mm
Height	40 in	1 m
Wheel width	20 in	508 mm
Wheelbase	23 in	584 mm
Centerline trench to outside edge of machine, left	15 in	381 mm
Centerline trench to outside edge of machine, right	8 in	203 mm
Spoil discharge reach	6 in	152 mm

Design specifications

OPERATION	U.S.	METRIC
Vehicle speeds		
Maximum transit reverse (tire)	5.8 ft/min	1.77 m/min
Digging chain speed		
6-tooth sprocket	348 rpm	
Spoils handling (single auger)		
Outer diameter	10.5 in	267 mm
Inner diameter	1.25 in	32 mm
Length	7 in	178 mm
Operating weight	225 lb	102 kg
POWER	**U.S.**	**METRIC**
Engine: Honda GS190 4-Stroke OHC		
Fuel: Gasoline		
Cooling medium: Air		
Number of cylinders: 1		
Displacement	11.4 in^3	187 cm^3
Bore	2.7 in	69 mm
Stroke	2.0 in	50 mm
Manufacturer's Power Rating Net Per (SAEJ1349)	5.2 hp	3.9 kW
Rated Speed	3600 rpm	

Design specifications

POWER TRAIN		
Ground drive transmission: Mechanical drive chain, controlled with one lever		
Digging chain drive: Mechanical drive chain, sheave clutch operated		
Spoils handling drive: Mechanical, attached to and rotates with mainshaft		
TIRES	**U.S.**	**METRIC**
Drive		
13 x 4.00-6	30 psi	207 kpa
FLUID CAPACITIES	**U.S.**	**METRIC**
Fuel tank	1.9 qts	1.8 L
Engine oil	0.61 qt	0.58 L

Design Calculations

- Power Transmission

$$n_{clutch} N_{clutch} = n_{sheave} N_{sheave}$$

- Force to move vehicle

$$F = W_g \frac{R}{1000} + W_g \frac{P_g}{100} + F_d$$

- Wheel torque

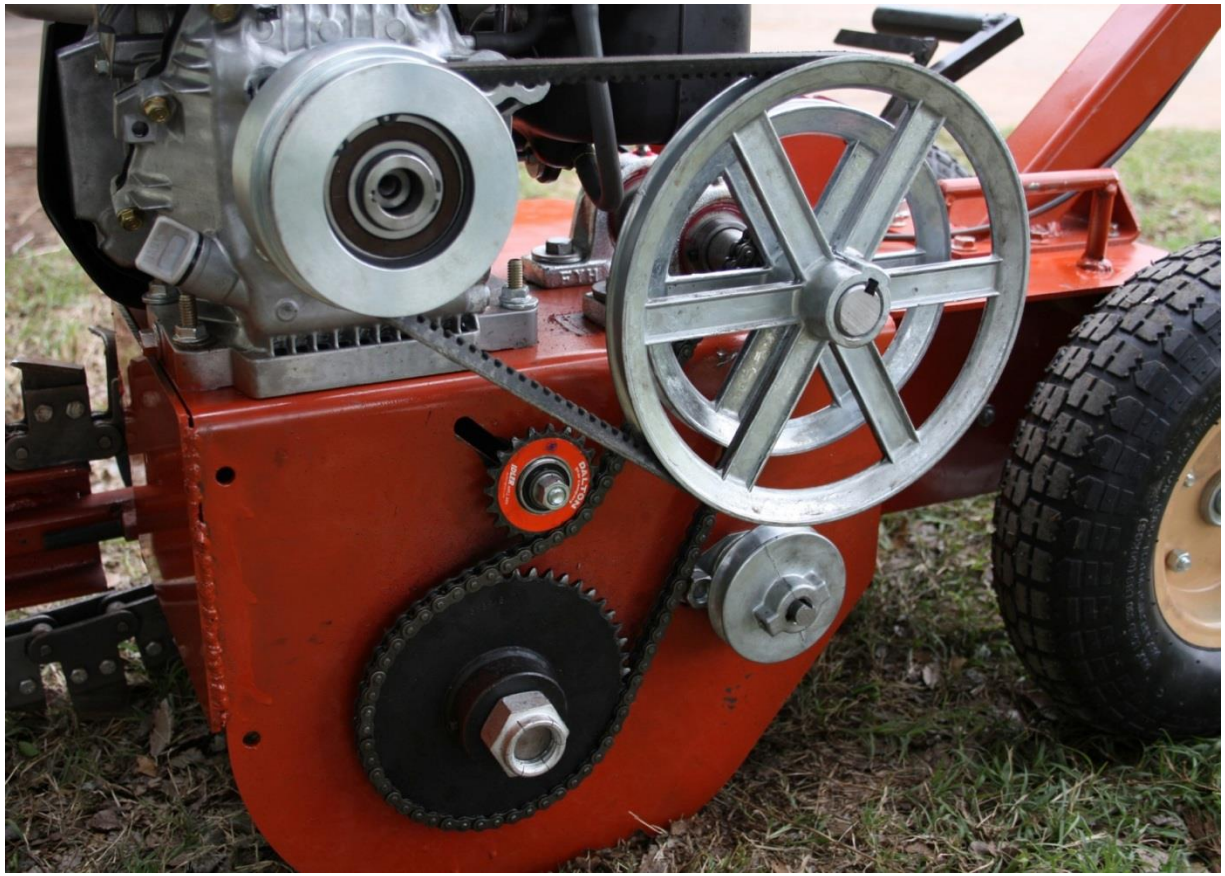
$$T_w = \frac{F \times r}{N_w}$$

Digging Chain/Boom

- 15 Alternating teeth
- Rotating at 348 rpm = 947 T/min
- Boom tightens by a set screw

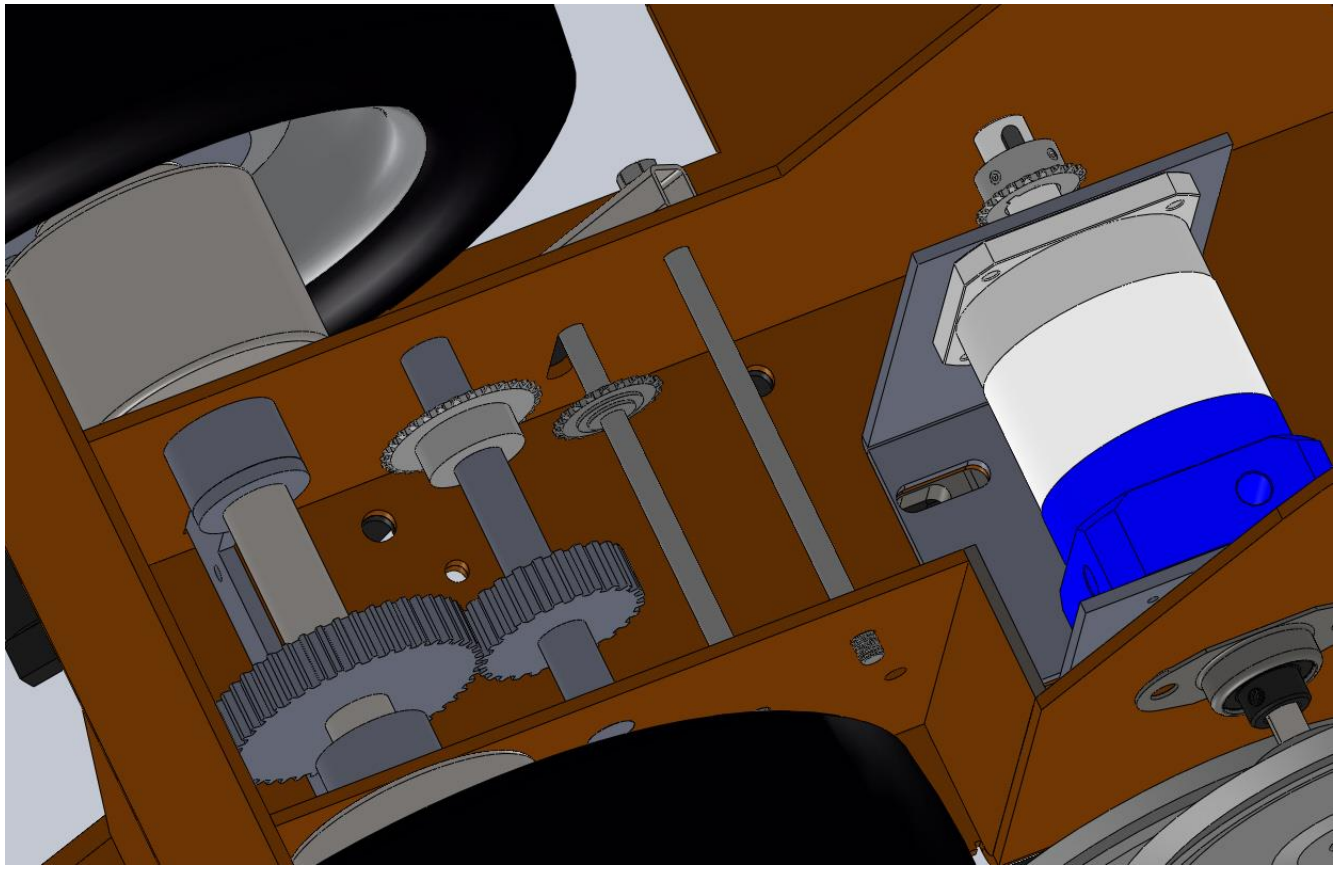
Depth Control

Power Transmission



- Engine output: 3600 rpm
- Mandrel shaft: 1600 rpm
- Mainshaft: 348 rpm

Ground-drive assist



- Planetary Output: 4.5 rpm
- Wheel shaft: 1.7 rpm
- Ground speed: 5.8 ft/min

How our design compares

	PT5	Vermeer	% diff.	Groundhog	% diff.
Max. Trenching depth	21in.	12 in.	43%	12 or 18 in.	43% or 15 %
Trenching Width	3 in.	3 in.	0%	3 or 4 in.	0% or -25%
Weight	225 lbs	270 lbs	17%	230 lbs	3%

Testing/Performance

Test 1

- Shaft bent because it was too small (1/2 in)
- Reordered parts for a larger shaft (1 in)
- Soil: dry

Test 2

- Plate holding boom and digging arm bent
- Welded two metal bars to either side of the plate
- Soil: moist

Testing/Performance

Test 3

- **SUCCESS!!** Trenched at all depths
- Trenching speed clocked at 0.65 in/sec or 3.25 ft/min at the 10.5 inch depth
- Soil: moist

Testing/Performance

Business Plan

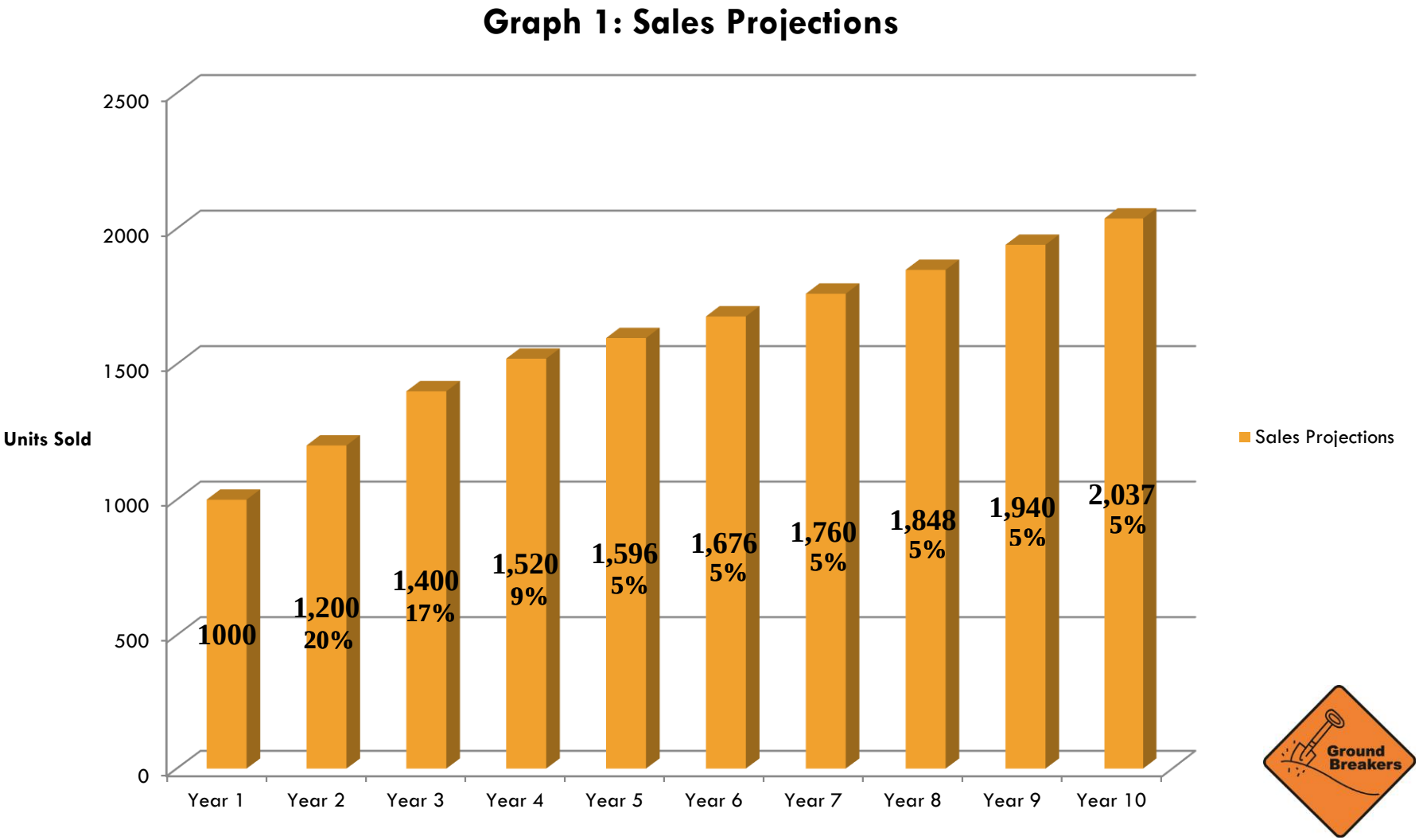
- Manufacturing:
  - DW's headquarters in Perry, Okla.
- Outsource:
    - Chain, bearings, belts and sheaves
- Teeth design from DW products

Business Plan/Market Potential

- Objective
  - Sell 1,000 units within 1 year of release date

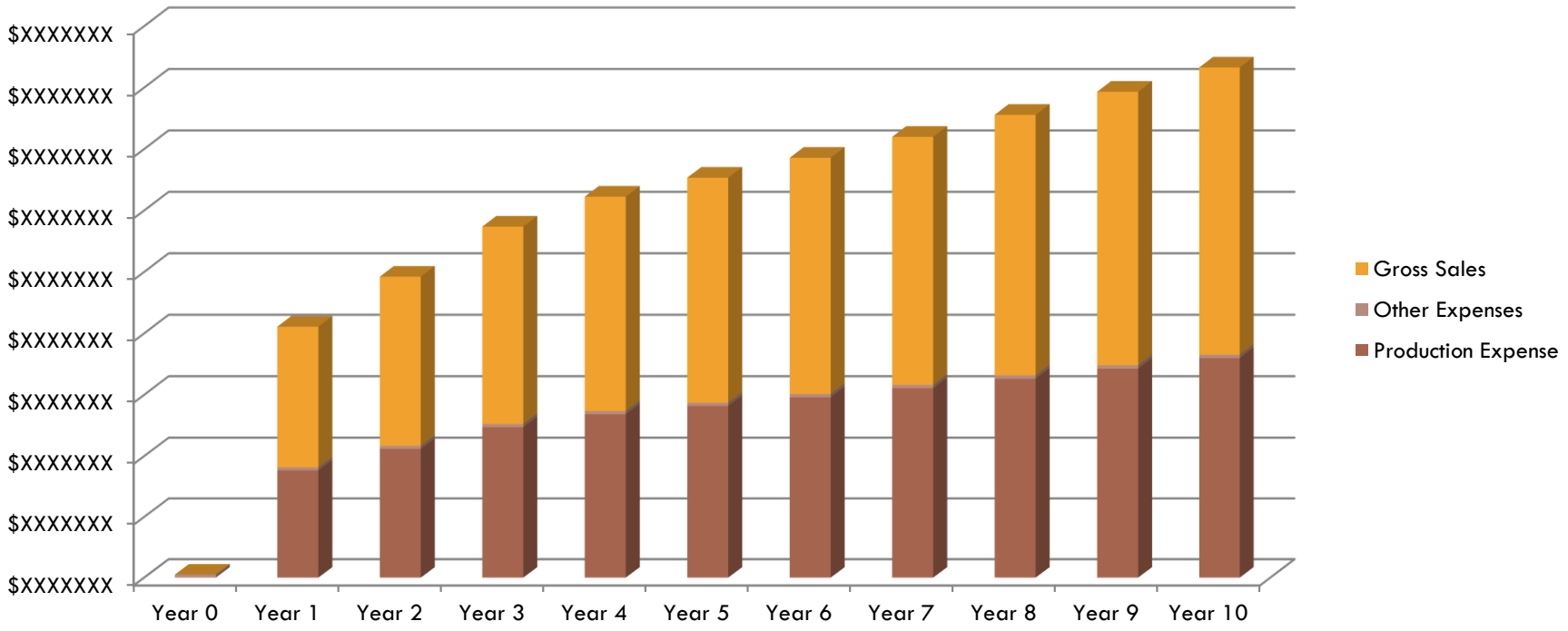
- Competitors' objectives
  - Sold less than 1,000 first year

Business Plan



Business Plan

Graph 2: Gross Sales against Expenses



*Gross sales before expenses

Product Name

PT5 Walk-behind Trencher

Unveil/launch product

- Unveil/launch product
- Feb. 2012 in New Orleans, La.
  - American Rental Association trade show
    - The Rental Show

Marketing/Campaign

- Advertisements
  - *Rental Management* (17,000 subscribers)
    - 12 ads – full-page; full-color w/bleed
  - *Construction Equipment* (76,000 subscribers)
    - 12 ads – half-page; full-color; no bleed

PT5 WALK-BEHIND TRENCHER

KEY FEATURES

GROUND-DRIVE ASSIST
TRENCH SPEED: 5.8 FT/MIN • 225 LBS
TRENCH DEPTHS: 4", 10.5", 16", 21"
TRENCH WIDTH: 3"

Ditch Witch

www.ditchwitch.com • 800-654-6481

Marketing/Campaign

- Media kits (flash drives)
  - Press release
  - Photos
- Tool kits (trade show materials)
  - Spec sheets
  - Product advantages
  - Pre-designed advertising
  - Video

Ditch Witch

PT5 WALK-BEHIND TRENCHER

KEY FEATURES

- GROUND-DRIVE ASSIST
- 5.8 FT/MIN TRENCH SPEED
- 5.2 HP HONDA ENGINE
- DEPTHS 4", 10.5", 16", 21"
- TRENCH WIDTH 3"
- 225 LBS

800-654-6481
www.ditchwitch.com

SPECIFICATIONS RT5

DEMENSIONS	U.S.	METRIC
TRENCH DEPTH, MAXIMUM	21 IN	533 MM
TRENH WIDTH	3 IN	76 MM
BOOM TRAVEL DOWN:	56°	
BOOM TRAVEL UP:	56°	
MAINSHAFT HEIGHT, DIGGING CHAIN	7.3 IN	185 MM
LENGTH	68 IN	1.7 M
WIDTH	20 IN	508 MM
HEIGHT	40 IN	1 M
WHEEL WIDTH	20 IN	508 MM
WHEELBASE	23 IN	584 MM
CENTERLINE TRENCH OUTSIDE EDGE OF MACHINE, LEFT	15 IN	381 MM
CENTERLINE TRENCH OUTSIDE EDGE OF MACHINE, RIGHT	8 IN	203 MM
SPOIL DISCHARGE REACH	6 IN	152 MM

OPERATION		
VEHICLE SPEEDS		
MAXIMUM TRANSIT REVERSE (TIRE)	5.8 FT/MIN	1.77 M/MIN
DIGGING CHAIN SPEED		
6-TOOTH SPROCKET (STANDARD)	348 RPM	
SPOILS HANDLING (SINGLE AUGER)		
OUTER DIAMETER	10.5 IN	267 MM
INNER DIAMETER	1.25 IN	32 MM
LENGTH	7 IN	178 MM
OPERATING WEIGHT	225 LB	102 KG

POWER		
ENGINE	HONDA GS190 4-STROKE OHC	
FUEL	GASOLINE	
COOLING MEDIUM	AIR	
NUMBER OF CYLINDERS	1	
DISPLACEMENT	11.4 IN^3	187 CM^3
BORE	2.7 IN	69 MM
STROKE	2.0 IN	50 MM
MANUFACTURER'S POWER RATING NET PER (SAEJ1349)	5.2 HP	3.9 KW
RATED SPEED	3600 RPM	

POWER TRAIN	
GROUND DRIVE TRANSMISSION: MECHANICAL DRIVE CHAIN	CONTROLLED W/ 1 LEVER
DIGGING CHAIN DRIVE: MECHANICAL DRIVE CHAIN	SHEAVE CLUTCH OPERATED
SPOILS HANDLING DRIVE: MECHANICAL	ATTACHED & ROTATES W/ MAINSHAFT

TIRES		
DRIVE		
13 X 4.00-6	30 PSI	207 KPA

FLUID CAPACITIES		
FUEL TANK	1.9 QTS	1.8 L
ENGINE OIL	0.61 QTS	0.58 L

Ditch Witch

PT5 WALK-BEHIND TRENCHER

KEY FEATURES

- GROUND-DRIVE ASSIST
- TRENCH SPEED 5.8 FT/MIN
- 5.2 HP HONDA ENGINE

- TRENCH DEPTHS 4", 10.5", 16", 21"
- TRENCH WIDTH 3"
- 225 LBS

www.ditchwitch.com • 800-654-6481

Marketing/Campaign

- Other trade shows
  - International Construction & Utility Equipment Expo (October)

- Social media
  - Facebook
  - Twitter
  - YouTube
  - Flickr

Marketing/Campaign

- Owner's Manual
  - Include with all trenchers at time of sale

Acknowledgments

- Ditch Witch
  - Jeff Smith
  - Mike Buck
  - Richard Sharp
  - Matt Collins
- OSU Faculty
  - Paul Weckler
  - Cindy Blackwell
  - Dan Tilley
  - Rodney Holcomb
- Other
  - Grant Leatherwood

INNOVATION OF PT5 WALK-BEHIND TRENCHER

April 28, 2011

Design of a small, walk-behind trencher

Table of Contents

1. Team Purpose

1.1 Mission Statement

Ground Breakers is devoted to exceeding our client's expectations within the marketing, design and profitability aspects of our resourceful products. Our intent is to provide a product promoting the company's growth and development within the competitive marketplace.

1.2 Problem Statement

Our objective is to market, design and produce a small, walk-behind trencher with design specifications provided by The Charles Machine Works Inc. that serves a specific audience within a profitable business plan.

2. Statement of Work

2.1 Statement of Work

The Charles Machine Works Inc. (Ditch Witch) of Perry, Okla., requested a design for a small walk-behind trencher with the following specifications: weight of 180 to 200 pounds; small engine size (around 5hp); maximum trenching depth of 20 inches with variable depths; and maximum trenching width of 3 inches. In addition, Ditch Witch would like to spend no more than $1,750 in production costs, in order to market the product between $2,000 and $2,500.

Comparing the potential prototype to key competitors, the small trencher will be targeted towards rental yards, in addition to construction and landscaping businesses. The prototype could be used by the construction and landscaping industries for preparing areas for electrical (TV and Internet) cables intended for homeowners. However, this product has the potential to be marketed through major home improvements stores, such as Home Depot or Lowe's – targeting homeowners with similar projects of installing fencing and irrigation.

2.2 Location of Work

Research, design and product development design is taking place in the Biosystems and Agricultural Engineering computer lab at Oklahoma State University in Stillwater, Okla. The construction of the prototype will take place in the Biosystems and Agricultural Engineering lab. Additional product testing will take place at Cowboy Motorsports, located at Lakeview and Western in Stillwater, Okla.

2.3 Period of Performance

Dec. 9, 2010, Ground Breakers are presenting preliminary designs and marketing strategies for constructing a small, walk-behind trencher. Beginning in January 2011 our group will gather materials to

begin the construction of the prototype. We are setting March 11, 2011, as our construction deadline. We are planning to compete product testing and revisions by April 1, 2011. This will allow for marketing and campaigning strategies to be completed for final presentations during dead week.

2.4 Deliverable Schedule

The following deadlines we must meet and complete in order for our group to be successful:

Date	Task	Deliver to
Nov. 1, 2010	Preliminary sketches Work Breakdown Structure	Team Instructors
Nov. 5, 2010	Marketing meeting with Matt Collins at Ditch Witch Return Groundhog T-4	Ditch Witch Ditch Witch
Nov. 15, 2010	Proposal Report – 1st draft	Instructors
Dec. 9-10, 2010	Fall Presentations	Instructors/Ditch Witch
Dec. 13, 2010	Self, peer & class evaluations Group Web page due	Instructors Instructors
Dec. 17, 2010 (nlt)	Deliver list of materials to client	Ditch Witch
March 11, 2011	Construction/building prototype	Team/Ditch Witch
April 1, 2011	Complete testing, repairs & revisions Begin marketing and campaigning strategies/tactics	Team/Ditch Witch Team
April 28-29, 201]1	Final Presentations	
May 6, 2011 (nlt)	Deliver prototype, research, final report and campaigning tactics	Ditch Witch

2.5 Special Requirements

Ground Breakers will need to travel (in January-March) to Perry, Okla., to visit Ditch Witch to receive various parts and an engine for the prototype. Further in the report, a list of materials is provided before the holiday in preparation of receiving the majority of our materials in January. However, in a team/client meeting on Nov. 19, 2010, Ditch Witch explained that some materials can take longer to

receive. In addition, we will be traveling to Ditch Witch periodically next semester to meet with the communications and marketing personnel as we develop a business plan and campaigning strategies.

3. Task List

3.1 Product Development

- Initial research **(Before Oct. 22, 2010 - completed)**
  - Ditch Witch's purpose, products and resources
  - Industry and market size
  - Competitors' purpose, product, resources, business plans and campaigning strategies
    - Product test top competing products to identify competing products' advantages/disadvantages
  - Identify audience **(Create survey – Nov. 12, 2010)**
    - Conduct survey to identify specific audience
    - Identify their needs and wants for uses of the product
  - Dealers and suppliers
  - Patents
  - Technical characteristics
  - Safety issues
- Business plan **(Nov. 2-14, 2010)**
  - Develop budget **(Nov. 8-14, 2010)**
  - Marketing strategies **(Nov. 2-8, 2010)**
  - Campaigning tactics **(Nov. 2-8, 2010)**

3.2 Design/Construction

- Review initial research and notes **(Oct. 22 – Nov. 14, 2010)**
- Sketch possible mini-trencher prototype(s) in Solid Works **(Oct. 22 – Nov. 14, 2010)**
- Develop list of materials and provide to client
- Build and construct mini-trencher prototype **(Beginning in January 2011)**

3.3 Testing/Evaluation

- Test prototype for product durability, reliability, maintenance needs and safety issues **(March 11 – April 1, 2011)**

- Evaluate prototype through product testing **(March 11 – April 1, 2011)**
- Adjust/repair prototype to fix any problems or improvements identified during product testing **(March 11 – April 1, 2011)**
- Finalize construction **(By April 1, 2011)**
- Retest, evaluate and improve as needed

3.4 Market product

- Web page for prototype, intended for Ditch Witch's website **(March 2011)**
- Trade Show materials/info-folders (audience: rental yards and homeowners) **(March – April 20, 2010)**
  - Brochures
  - Spec sheets/product testing results
  - Quote sheet
  - Safety sheet
  - Create website management tactics to track Trade Show traffic on site
- Field rep info-folders (audience: rental yards) **(March – April 20, 2010)**
  - Include spec sheets,
  - safety sheets
  - market pricing,
  - product testing results,
  - business cards,
  - performance rating brochure
- Video **(Film at final prototype testing on April 1, 2010)**
  - Video final product testing to promote prototype to client and potential audiences
  - Capture some features to differentiate prototype from competitors
- Create advertisements for primary trade publications **(April 2011)**

4. Market Research

4.1 Demographic characteristics of audience

Although Ground Breakers' goal is to make the small, walk-behind trencher accessible and usable for anyone, we narrow Ditch Witch's audience to males between the ages of 25 and 55 – regardless of industry. In verbal communication with Matt Collins and Jeff Smith of Ditch Witch on Nov. 5, 2010, the demographics of the audience we identified is synchronized with the demographics they plan to target in their marketing efforts.

4.2 Industry performance

The following analysis of three key industries targeted includes economic status, general characteristics, psychographic characteristics, and industry size and growth. Supporting industry reports can be found in Appendix C.

Rental Yards

According to the IBIS World Industry Report, "Tools, Equipment and Other Rental Centers in the U.S.," the rental industry has seen a 4.7 percent decline since 2005, falling to $4.42 billion in revenue. However, IBIS World Reports predict the industry revenue to improve by 2015, rising to an average annual rate of 8.2 percent and $6.56 billion. As of October 2010, the rental industry has 7,515 contributing businesses. Positive predictions of the U.S. real estate market encourage economic growth in residential, industrial and commercial construction industries. Although industry reports provide evidence that residential construction is currently "hindered by poor development conditions," (Andrews, October 2010, p. 5), "the value of the industry includes new construction and renovations of single- and multi-family homes" (Andrews, October 2010, p. 5). A significant share of the industry originates from leasing equipment to homeowners, landscapers and contractors.

According to Jeff Smith, Ditch Witch design team manager, rental yards receive more return on investment within one year of purchase, receive profit in the second year of ownership, and liquidate the used equipment during the third year of ownership. Furthermore, rental yards lease equipment to contractors expecting to receive greater returns on investment in managing equipment — rather than building with it. In addition, Smith said rental yards receive depreciation tax deductions. Therefore, these reasons motivate rental yards to offer highly rentable products for the specified geographic region, in addition to demanded products for propelling industries.

Large rental firms in the U.S. have managed the five-year (2005-2010) decrease by diversifying their product-line – offering a wider range of equipment and services. Since Ditch Witch is a medium-sized supplier, offering another product to a wider audience is in the company's economic favor.

New Construction (Residential)

According to the IBIS World Industry Report, "Single-Family Home Building in the U.S.," about 327,320 businesses contribute to the single-home construction industry revenue of $168.5 billion. Since 2005, the industry has seen a 20.4 percent decline. However, the 2010-2015 annual growth rate is projected to increase by 16.5 percent to $361.57 billion. In 2011 alone, the industry is expecting an 11.4 percent increase in revenue growth. Although real estate values, housing demand and financing activity are estimated to improve, IBIS World does not project the industry revenue to peak above the 2005, $526.63 billion mark in the near future.

According to IBIS World, "the number of households increases with strong economic conditions, as individuals increase living expenses, disposable income and consumer confidence." (Andrews, August 2010, p. 6). As disposable income fluctuates, the demand for industry services reflects that inconsistency. Unemployment is also a key contributor in industry performance. Therefore, additional spending on renovations and personal projects are preserved until economic conditions pick up. As a country, consumers, businesses and developers rely heavily on financing for business and personal purchases. IBIS World offers the Great Recession – which technically has ended, was due to the tightening of the credit markets because the U.S. society is heavily dependent on debt. Since 2007, businesses and individuals have not had the funding available to promote growth in the real estate and construction industries.

IBIS World estimates the housing industry to begin feeling a demand for new construction homes between August 2010 and 2015. The organization also predicts industry employment and wages to increase by 11.9 percent and 13.3 percent within this time frame. The rise in consumer profitability will promote industry growth, increasing the expected number of industry enterprises to 582,634. The industries positive predictions to 2015 support economic growth and the development of small trencher to compete in the market.

Landscaping (Designing and planning)

According to the IBIS World Industry Report, "Landscape Design and Planning Services in the U.S.," the landscaping industry had a 2.1 percent decrease in revenue since 2005. Like many other industries currently, reduced annual income has forced companies to cut employees and wages. Although, IBIS World reports the landscaping industry reacts to the construction industry's economic status. Since the construction industry saw a 20.4 percent decline, the demand for landscaping services obviously decreased. However, although most industries have seen a drastic decrease in economic growth, it is apparent the landscaping industry has seen a much smaller strain in cutting costs – especially, compared to the construction and real estate industries.

Approximately 84.7 percent of landscape design businesses are small players or sole proprietors and produce 18.8 percent of the industry revenue. With 35,832 businesses in the industry, IBIS World predicts the landscaping industry to increase by 5.1 percent or $7.5 billion by 2015 since demands for landscape design are expected to increase.

4.3 Current and potential market size

In conducting research to rent potential competing products, we found nationwide and local rental yards in Oklahoma only carried a limited number of small, walk-behind trenchers. Most rental yards contacted did not offer two competing products. After contacting 15 rental yards in Oklahoma, only ABC Equipment Rental of Tulsa, Okla., carried a Ground Hog T-4. ABC Equipment Rental quoted Ground Breakers $150 rental fee per day, $9.50 environmental fee, $18 damage waiver fee, and $200 refundable deposit. However, most Home Depot locations in Oklahoma City and Tulsa carried a Groundsaw EZ-1900. The rental rate for the Groundsaw EX-1900 was $60 for 12 hours and $85 for 24 hours. In addition, many rental yards and home improvement stores (Home Depot) advertised online the availability of the Ground Hog T-4 or the Vermeer RT60, but did not actually have the product available for rental usage in Oklahoma. Many times, their employees did not have knowledge of these products. Currently, we have yet to locate a Vermeer RT60 in Oklahoma Rental Yards. According to Richard Sharp, Mike Buck and Jeff Smith, on Sept. 29, 2010, competing small, walk-behind trenchers may not have the capability to perform in Oklahoma soils and designing a prototype suitable for Oklahoma soils has increased potential to serve other comparable geographic regions – expanding our geographic area.

4.4 Market research

Before designing a prototype for Ditch Witch, Ground Breakers set a goal to product test competing small trenchers. However, Ground Breakers was only able to locate one competing trencher, due to availability at Oklahoma rental yards.

On Oct. 25, 2010, Ground Breakers tested a Ground Hog T-4, a top competing trencher, received from Ditch Witch at no cost. The product testing demonstrated product performance and assisted Ground Breakers in designing the prototype for Ditch Witch

Another aspect to include when marketing the new prototype trencher is mode of transportation. Since the trencher will be less than 200 pounds (which is light enough for two to three people to lift), Ditch Witch specified the need for an alternative approach for customers to transport the product. Ground Hog offers a transportation device for the Ground Hog T-4 to hook on a receiver hitch, which can be hauled with SUV-like vehicles. Although we have minimal research completed in this area, we feel a comparable design is in Ditch Witch's favor to offer in conjunction with the small trencher. However, Ground Breakers is not responsible and does not guarantee a design of a transportation/receiver hitch prototype to include in the project.

4.5 Applicable standards and regulations

Heavy Construction Equipment Rental & Leasing

According to the IBIS World Industry Report, "Heavy Construction Equipment Rental & Leasing," OSHA regulations requiring all equipment to be continually monitored, modified, and adjusted to comply and meet any changes in standard and regulations for its use in operation. OSHA has the support of the United States Standards regulations. If rental businesses fail to give sufficient or adequate information on safe use to custom hires before renting the equipment they are liable under the liability regulations.

Land Development in the US

> *"The industry operates in a highly regulated environment, as contractors must comply with a wide range of state and local laws and regulations relating to: land use zoning, treatment of waste, construction materials, density requirements, building design, and minimum elevation of properties."* (Andrews, August 2010, p.31-32) This industry is heavily regulated and has many different regulations.

Single-Family Home Building in the US

"There is no national regulatory control of industry participation although state housing authorities impose varying methods of regulating the industry and participants are required to register or be licensed to undertake business within each state or district jurisdiction. Health and Safety regulations require that protective clothing and helmets be worn on site and that safe conditions are provided for the workers (e.g. scaffolding and ventilation). The Federal Occupational and Safety Health Administration (OSHA) enforce standards for the construction industry which are contained in Title 29 of the Code of Federal Regulations (CFR) Part 1926. State authorities assess and enforce this code. Currently, a broad range of codes govern activity in this industry including, general building codes, residential codes, mechanical codes, plumbing codes, electric codes, fire codes, accessibility codes, zoning codes, state codes, local codes and ordinances." (Andrews, August 2010, p. 32-33).

4.6 Acceptance Criteria/Safety information

After searching safety regulations, our most dependable source was Ditch Witch. According to our client, the following are important safety features Ground Breakers is aware in order to provide a small, walk-behind trencher.

- Kill/stop switch, safety chain guard over the chain boom
- Keep others at least six feet away
- Use personal protective equipment
- Color codes for utility markings
- Use proper tie-downs for transportation
- Provide information about 811
    - (a service that marks where telephone, gas and other cables are buried)

4.7 Key industry gatherings

According to the Association of Equipment Manufacturers, trade shows are the best way to accomplish business-to-business marketing strategies. In addition, most product research is conducted at trade shows. Ditch Witch attends 12 major industry association trade shows annually, including the Rental Industry Association, International Construction and Utility Equipment Exposition. The Rental Industry Association trade show attracts leaders serving the construction and homeowner industries. According to the International Construction and Utility Equipment, its annual exposition attracted: 12

percent of phone and cable utility contractors; 2 percent of landscaping businesses; 15 percent equipment dealers; distributors and rental yard; and 9 percent of equipment manufacturers. Therefore, about 30 percent of attendees would be primary audiences in promoting the small trencher.

4.8 Key trade publications

According to Ditch Witch, the company utilizes the following key trade publications to promote product development: *Construction Equipment*; *Equipment World*; *Landscape and Irrigation*; *Landscape Contractor Magazine*; and *Rental Equipment Register*. Supporting research can be found in Appendix D.

Construction Equipment, a paid-subscription publication, circulates to 76,000 managers and construction equipment fleets. Their website, in conjunction to the publication, offers evaluations of machinery, a comprehensive directory of manufacturers, distributors and rental outlets, and a database of equipment specifications allowing individuals to compare competing models. The monthly publication provides the latest in new product information, such as; product development; product technology; and machine acquisition; disposal and maintenance. Presenting ideas and insight for equipment professionals is the main purpose of the magazine.

Equipment World, a paid-subscription publication, data-driven circulation targets leaders in the heavy construction industry with a monthly subscription. The publication credits itself for editorial integrity, circulation intelligence and innovative advertising and marketing programs since 1989.

Landscape and Irrigation, a paid-subscription, provides a monthly magazine to decision makers including residential contractors, commercial ground managers, public works professions, and irrigation and water management professionals within the landscaping industry. The publication offers advice from industry professions, coverage of specified projects, details on the latest products and innovations and top international news.

Landscape Contractor Magazine offers the publication through a free print and online subscription. The website did not give a specified target audience or circulation. However based on experience within print media, most free-subscription publications have a shorter shelf-life and do not reach the intended audience. Many times readers throw away the publication after reading it once. Instead, readers who purchase subscriptions are more apprehensive to throw away a publication they had to purchase. (Lisa Brown, member of Ground Breakers, interned for a paid, print publication – *High Plains Journal* – and this is understood within the publication industry.) In addition, these readers will be more likely to refer back to past issues when they keep them longer.

Rental Equipment Register reaches 21,204 entities spending $21.8 billion annually in the rental industry, providing advertisers a valuable audience to target. Through *RER*'s magazine and website, reports, product wire e-newsletters, buyer's and rate guides, industry event calendar and special reports are offered an innovation marketing scheme to reach a wide audience.

4.9 Further Market Research

Product	Production Cost	Retail Price
Vermeer RT60	$3,200	$3,800
Ground Hog T-4	$2,400	$3,000

*Information gathered from Matt Collins, Ditch Witch project manager, on Nov. 18, 2010.

4.10 Management team and key people involved

The Ditch Witch management team includes Jeff Smith, design team manager; Mike Buck, mechanical designer; Richard Sharp; and Matt Collins, product manager. Additional key people include Tiffany Sewell-Howard, CEO and Ed Malzahn, founder of Ditch Witch and president of the Board of Directors.

4.11 Product line

The product line for the small trencher prototype will best fit in the walk-behind trencher line that Ditch Witch currently offers. Ditch Witch offers three walk-behind trenchers. However, their current products are designed for large-scale trenching projects. The smallest walk-behind trencher Ditch Witch offers weighs 930 pounds with a trenching depth of 30 inches and width of 4 to 6 inches. To make the product more appealing to small business owners and homeowners, Ditch Witch is planning to release a product on much smaller scale. For the small, walk-behind trencher prototype, we anticipate low maintenance and repair costs for Ditch Witch and its customers, as we are trying to match our design to better incorporate parts currently carried and used in their related products. Anticipated input suppliers include Honda, Briggs & Stratton, Ditch Witch and other small part suppliers (will be furthered researched).

4.12 Manufacturing expertise and capacity

Located on 80 acres in Perry, Okla., Ditch Witch has the manufacturing expertise and capacity which include the ability to make rods and chains, in addition to assembling, painting and testing their products in their factory.

4.13 Marketing Techniques

Ditch Witch uses a website, Ditch Witch Mobile, the Underground (Ditch Witch's publication), various trade shows, dealers, sales representatives and product guarantee as the company's main marketing techniques.

4.14 Brand, Reputation and Trademarks

"Ditch Witch" was something Ed Malzahn called his compact trencher invention in 1949. As the name and logo implies, consumers developed an association of compact trenchers with Ditch Witch. Like other companies, Ditch Witch's reputation goes back to the product and customer service. Current Ditch Witch trenchers carry the tradition of the original design consisting of "outstanding power, rugged frames, operator convenience, extraordinary durability, and lengthy list of innovative standard features." (Ditch Witch, 2010, Trenchers and Plows Web page). Providing product guarantees, customer satisfaction, appreciation and respect.

The Charles Machine Works Inc. has the following Trademarks: Ditch Witch®; CMW®; Subsite®; Jet Trac®; AutoCrowd®; Fluid Miser®; Roto Witch®; Super Witch®; Pierce Airrow®; and *The Underground*®.

4.15 Distribution/dealers

Ditch Witch has dealerships nationwide. Their dealerships and sale representatives promote distribution to rental yards and major construction landscaping companies. When contacting rental yards for product testing, often times the business did not carry light-weight trenchers. However, every business offered either the RT12 or RT10 – popular Ditch Witch models. This first-hand experience demonstrates that Ditch Witch has accomplished a positive reputation for the product, in addition to distributing their products to local and nationwide dealers.

4.16 Ditch Witch's financial condition

According to Matt Collins in a meeting on Nov. 5, 2010, Ditch Witch will be financing itself in the development of the new small, walk-behind trencher. With Ditch Witch researching new product development of a small-scale product mainly to stay competitive in their markets, demonstrates Ditch Witch will continue to serve as a main contributor in their industry. In addition, their broad distribution also provides us with good indication Ditch Witch is not any major financial trouble. However, we have not been given Ditch Witch's balance sheet, income statement and cash flow data. We were only provided the Pro Forma Overview for the small, walk-behind trencher – found in Appendix A.

4.17 Available financing

Ditch Witch offers two financing options through Ditch Witch Financial Services. The first financing option is the Ditch Witch®Platinum Plus Card, intended for purchasing professional grade Ditch Witch parts, maintenance and service. The card promotes "enhancing businesses' buying power, opening credit lines, and tracking expenses with an easy-to-read monthly statement." (Ditch Witch, 2010, Financing Web page). With a dedicated line of credit, the card requires of no annual fee, no interest charged if the balance is paid in full monthly, minimum 25-day grace period, flexible repayment terms, and quarterly special promotions. Supporting research can be found in Appendix A.

Large equipment purchases are offered in the second financing option. Ditch Witch's experienced professionals help business buyers map their financing plan, such as monthly payments, rent-to-own, or customized leases.

4.18 Market Shares

Ditch Witch does not publish market share data since it is a privately-owned company.

5. Design Research

5.1 Scientific Literature Review

The trenchers we found similar to our conceptual ideas have many of the same specifications and features included in their design. Some characteristics on existing products include chain and rotary trenching types, shark and bullet type digging blades, trenching depth control, loading handles, and ground drive assists. Table 1 below shows specifications by each brand and model.

Table 1 Existing Product Specifications

Brand/Model	Engine/HP	Trench Type	Max Depth	Width	Weight
Vermeer RT60	Honda 5.5	Chain	12"	3"	270 lbs
E-Z Trench 9100	Honda 8	Rotary Disk	13"	2.5"	250 lbs
Kwik-Trench KT100	B&S 5.5	Direct Chain	8"	3"	430 lbs
Kwik-Trench KT2400B	Honda 8	Triple V-belt	12"	4"	216 lbs
Ground Hog T-4	Honda 5.5	Chain	12" or 18"	3" or 4"	230 lbs

5.2 Durability, reliability, maintenance costs, maintenance programs

The durability, reliability and maintenance aspects of this project are similar to the existing types of small trenchers and the companies producing them. Most of the companies producing small trenchers are relatively large, with many resources to provide to their products and their customers. Along with operator's manuals to show the customer how to use the machine, the companies also provide troubleshooting information by customer service representatives via phone and e-mail. Maintenance resources are available within these existing companies to provide the customers with replacement parts.

5.3 Characteristics Technically Possible

Most of the features we found on existing products are relatively similar within their design. With the design intent of mini trenchers, many components on larger trenchers are undesirable for smaller trenchers due to size, weight and cost limitations. Simplicity of design is essential for small trenchers to support functionality, size and weight limitations. Some characteristics on larger trenchers are hydrostat drive control, axle differential lock for straight trenches, a pivot on the trencher arm for curved trenches, and electrical switches and components. All of these characteristics are technically possible. However, they will not satisfy the limitations for size, weight and cost. Characteristics technically possible would be depth control, ground drive assist, loading handles, axle lock for transporting, emergency shutoff, small attached toolbox, soft handle grips, and tie-down hooks.

5.4 Safety Issues

Safety issues that must be addressed include, but are not limited to, a kill switch and a leveling system. Since this is a heavy piece of machinery used to cut into the ground, it has sharp moving parts that are dangerous. If the machine is operated on unlevel ground it could easily tip over, potentially causing serious harm to the user. Therefore, we need to address the issue of having a way to keep the trencher level on unlevel ground. If the trencher should begin to tip or if the user happens to fall away from the trencher a kill switch is needed, comparable to kill switches used on water-jets.

5.5 Patent Searches

We discovered three patents relevant to our trencher. Each patent's abstract, claims, and drawing sheets can be found in the Appendix E.

PN 7805864: The walk-behind trenching machine patent is relevant to our design of the small trencher prototype because it incorporates a trenching boom with an endless chain, which can be

movable between an operating position and a transport position. This patent is useful since Ditch Witch wants a light-weight, easily transported small trencher prototype.

PN 6832443: The cutting chain patent, which was invented by our sponsor Ditch Witch, is a very useful and important patent. The chain is designed to more effectively and efficiently drag out soil, broken materials, and other underground materials to the surface providing a much cleaner trench, improving the trenching performance of the cutting chain. We could use this design to help make a smaller chain for the small trencher prototype.

PN 6658768: The trencher patent is relevant because it is designed to dig a curved trench and transition between excavating a straight section and curved section of trench. We could use this in the design to help widen our customer focus since not everyone needs to dig straight section trenches all the time.

5.6 Physical Testing & data collection

Physical testing and data collection included testing an existing Ground Hog T-4, supplied by Ditch Witch. Measure components and understanding of its design were also analyzed.

5.7 Modeling and Simulation

Three-dimensional Solid Works CAD drawings will model the conceptual machine. Animated simulation of the device will be produced using the CAD software. From a bill of materials, the parts will be drafted to scale and sent to the Ditch Witch Product Development Center or BAE shop for fabrication. The machine will be assembled by Ground Breakers and any modifications will be completed, as needed.

6. Product Specifications

6.1 Production Specifications

The Charles Machine Works Inc. (Ditch Witch) of Perry, Okla., requested a design for a small walk-behind trencher with the following specifications: weight of 180 to 200 pounds; small engine size (around 5hp); trenching depth of 21 inches and trenching width of 3 inches. There were no specifications provided on how fast the trencher must dig. In addition, Ditch Witch would like to spend no more than $1,750 in production costs, in order to market the product between $2,000 and $2,500.

7. Customer Requirements

7.1 Customer Requirements

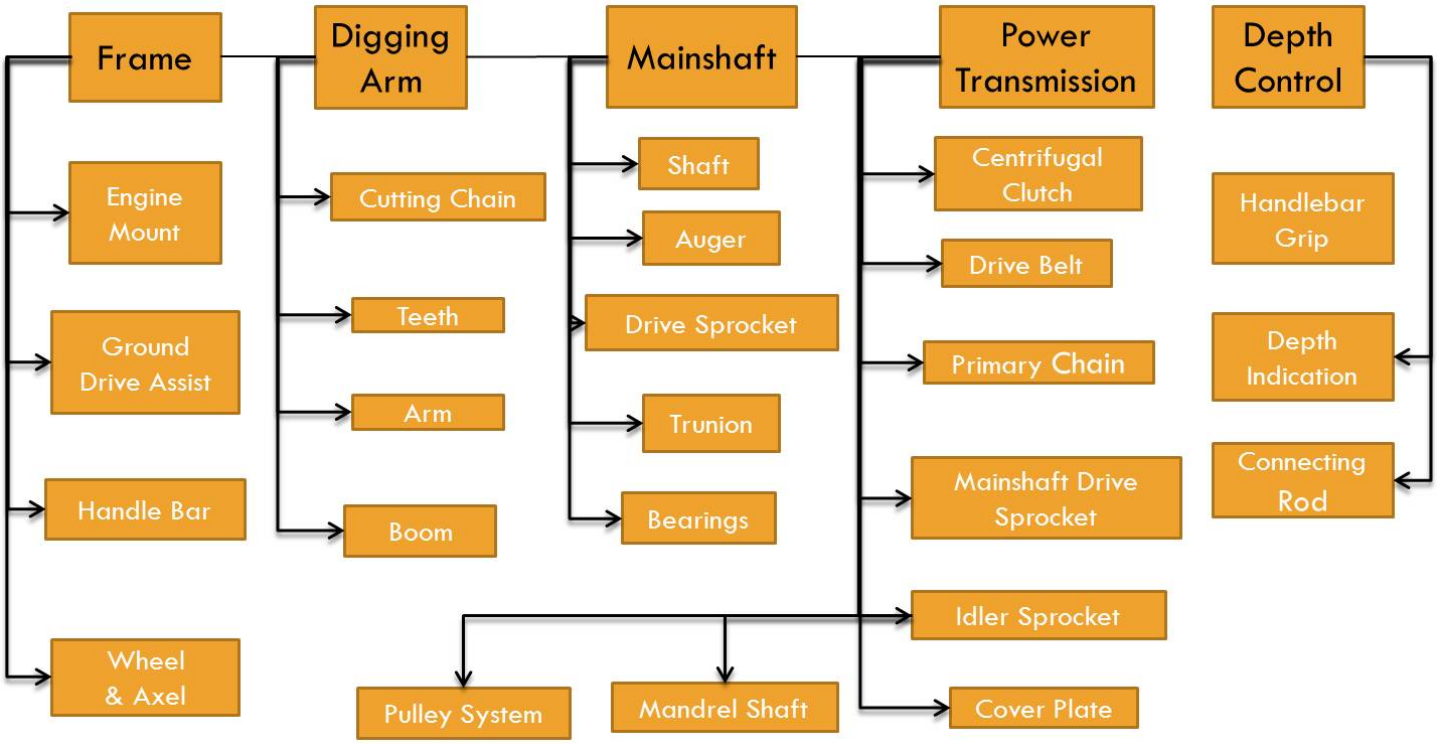
Ditch Witch has given specifications, but no requirements for the small, walk-behind trencher. However, from meetings and personal conversations with Jeff Smith, Ground Breakers comprehends that including a ground-drive assist in our design will be more accepted than if we do not include it. In addition, online forums suggest consumers are willing to pay more a product with ground-drive assist, such as the Vermeer RT60. (Landscape Design & Installation Forum). Therefore, Ground Breakers will incorporate a ground-drive assist in our final design.

8. Design Concepts

8.1 Generation of Design Concepts

We have begun and are continuing to generate design concepts to meet the specifications provided by our client, provide a reliable, customer-oriented product and produce an aesthetically marketable product. The process of generating design concepts consisted of research and testing of currently existing products similar to our ideological concepts. Our designs are created from existing parts and products with an emphasis on simplicity of design, constructability and performance, while minimizing the overall weight.

8.2 Design Process



8.3 Design Concepts

Figure 1: Honda GS190; 5.2hp; 30.4 lbs. This engine will provide suitable power for the digging chain as well as the ground-drive assist.

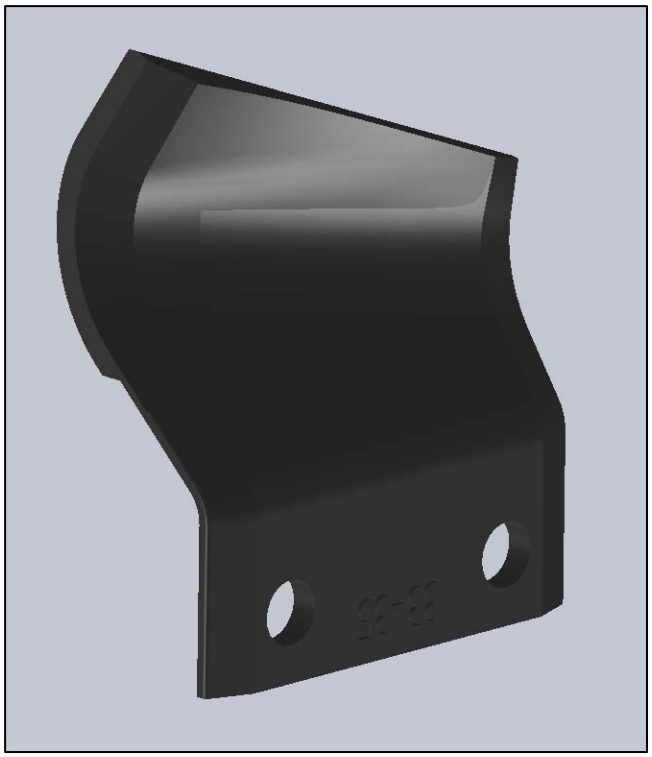


Figure 2: Digging teeth that will be attached to the chain. These teeth are used Ditch Witch's current trenchers.

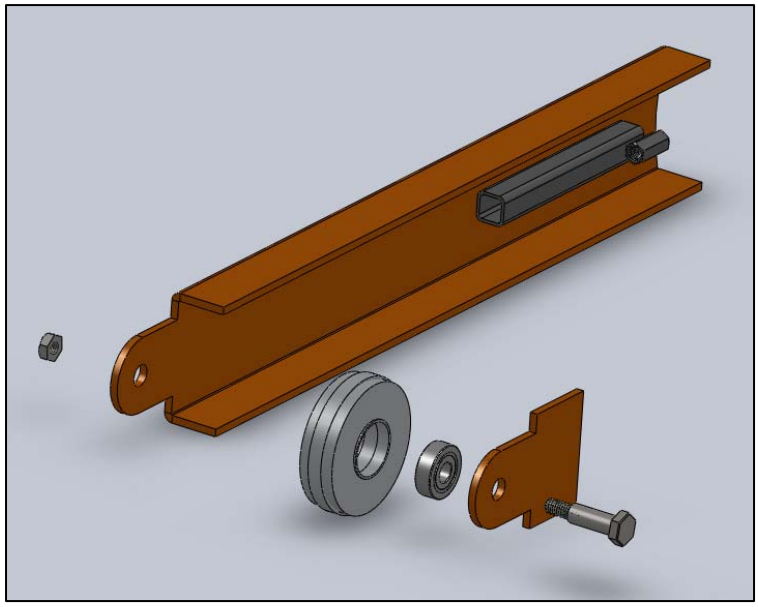


Figure 3: The figure above represents the digging arm in which the digging chain will rotate around.

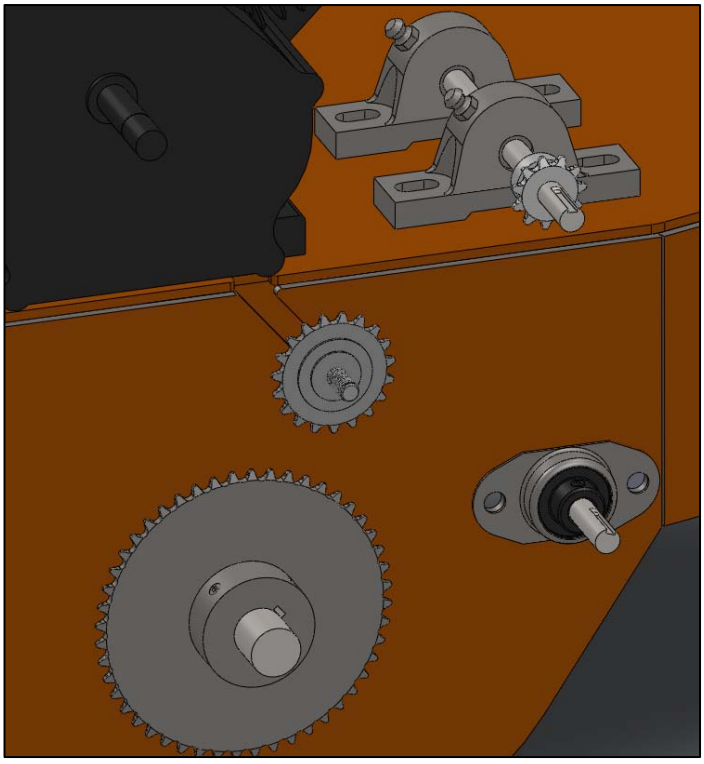


Figure 3: The figure above shows the layout for the power transmission. The mandrel shaft will be driven by a sheave/v-belt from the pto. The mandrel shaft will drive the main shaft by a chain/sprocket, as well as the input shaft for the planetary gear train for the ground drive assist.

9. Design Evaluation

9.1 Feasibility evaluation of possible designs

We have selected the Honda GS190 engine, which, compared to other engine models, will provide the product with sufficient power and torque ratings for the trencher and ground drive assist. The power transmission will consist of a mechanical friction clutch, which will engage the trencher when the rpm is increased, connected by a v-belt to a sheave with a small chain sprocket on the same shaft. The small sprocket will drive a large sprocket connected to the main shaft of the trencher.

The ground drive assist will be powered from the power transmission as well. A planetary gear train will be used for a speed reduction for the wheel shaft. The shaft from the planetary gear train will have a small gear which will drive a larger gear on the wheel shaft for speed reduction. The drive assist will be controlled from the handle bar, allowing the user to engage it when needed. The

The alternating teeth design is on most trenching cutting chains and is the best design for us to use in order for the teeth alignment to achieve optimum soil cutting. They will be attached to the chain to fit our specifications and design, and aligned alternating from one tooth on the left to one tooth on the right.

The frame will be fabricated with 3/16" thick sheet metal, which will minimize the weight, while providing a sufficient amount of material for strength and stability.

9.2. Determination of suitable designs

Determining the shaft sizes according to torque was our first step. The main shaft was calculated to be one inch in diameter, while the mandrel shaft was calculated to be one-half inch in diameter. Our rpm for the chain sprocket/main shaft was desired to be ~380 rpm. For this desired speed, an overall speed reduction was calculated to be 9.5:1, which was met through a reduction from sheaves and a reduction from sprockets.

For the ground drive assist, a desired rpm was that less than 2 rpm. For this, we have selected to use a planetary gear train to largely reduce the shaft speed.

The chain was figured to be a #35 (3/8" pitch). The small sprocket has 11 teeth, while the large sprocket has 45 teeth.

The angle for our maximum trenching depth was determined to be 40 degrees from the horizontal.

10. Project Schedule

10.1 Gantt Chart

See Appendix A for a detailed project schedule.

11. Project Budget

11.1 Budget

Product	Product Specification	Product/ Order Number	Vendor	Quantity	Price
Engine	Honda GS190			1	$ 294.00
Clutches	spring clutch			2	$ 140.00
	sheave clutch			1	$ 90.00
Steel Shaft	20" of 1" diameter			1	
	10" of 0.5" diameter			1	
Planetary Gear Train				1	$ 300.00
Sprockets	11T, 45T, 19T				$ 40.00
Sheet Metal	~1500 sq. in. of Gauge 7			1	
Bolts/Nuts					$ 50.00
Sheaves	2-9" Sheaves, 2 belts				$ 42.00
Bearings	2 tapered, 2 flange, 2 base, 1 ball			2	$ 155.00
Chain	2080H			1	$ 120.00
Digging Teeth	Teeth			70	
Wheels				2	$ 80.00
Labor	Determined Spring 2011				
		Grand Total		83	$1,311.00
		Specified Cost Constraint			$1,750.00

12. References

12.1 Conversations/Personal Communication

Smith, Jeff, Mike Buck and Ditch Withc of Ditch Witch, business meeting/personal communication in Perry, Okla., on Sept. 29, 2010.

Smith, Jeff and Matt Collins of Ditch Witch, business meeting/personal communication in Perry, Okla., on Nov. 5, 2010.

Smith, Jeff, Mike Buck and Richard Sharp of Ditch Witch, business meeting/personal communication in Perry, Okla., Nov. 19, 2010.

12.2 Related research

Andrews, Robert J. (August 2010). IBIS*World* Industry Report 23311: Land Development in the US. Publisher: IBIS*World* Inc.

Andrews, Robert J. (August 2010). IBIS*World* Industry Report 23321: Single-Family Home Building in the US. Publisher: IBIS*World* Inc.

Andrews, Robert J. (October 2010). IBIS*World* Industry Report 53231: Tools, Equipment & Other Centers in the US. Publisher: IBIS*World* Inc.

Bolay, Brent. (Sept. 1, 2002). Selecting the Right Trencher. On Versalift East. Retrieved on Oct. 15, 2010, from http://www.versalifteast.com/articles/selectingatrencher.htm.

Culbert, Kevin. (June 2010). IBIS*World* Industry Report 54132: Landscape Design & Planning Services in US. Publisher: IBIS*World* Inc.

Wilson, Michael. (September 2010). IBIS*World* Industry Report 53241: Heavy Construction Equipment Rental & Leasing in the US. Publisher: IBIS*World* Inc.

12.3 Patents

United States. Department of Commerce. Patent and Trademark Office. *Cutting Chain.* Piel, Martin Roy, et. al. PN 6832443. Retrieved October 20, 2010. http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=6832443.PN.&OS=PN/6832443&RS=PN/6832443.

United States. Department of Commerce. Patent and Trademark Office. *Trencher*. Bainter, Wesley Allen. PN 6658768. Retrieved October 20, 2010. http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=6658768.PN.&OS=PN/6658768&RS=PN/6658768.

United States. Department of Commerce. Patent and Trademark Office. *Walk Behind Trenching Machine*. Azure, John P., et. al. PN 7805864. Retrieved October 20, 2010. http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=7805864.PN.&OS=PN/7805864&RS=PN/7805864.

12.4 Websites

(2010). About Equipment World. On Equipment World. Retrieved on Oct. 20, 2010, from http://www.equipmentworld.com/about-equipment-world.

(2010). About Landscape & Irrigation. On Landscape and Irrigation. Retrieved on Oct. 20, 2010, from http://tinyurl.com/257jdrg.

(2010). About the Magazine. On Landscaping & Groundspeeking. Retrieved on Oct. 20, 2010, from http://lg.baumpub.com/magazine/about.

(2010). About Us. On Construction Equipment. Retrieved on Oct. 19, 2010, from http://constructionequipment.com/page/about-us.

(2010). Ditch Witch Safe. On Ditch Witch. Retrieved on Oct. 20, 2010, http://ditchwitch.com/safe.

(2010). Financing. On Ditch Witch. Retrieved on Oct. 17, 2010, http://ditchwitch.com/safe/.

(2010). Financing. On Ditch Witch. Retrieved on Oct. 20, 2010, http://www.ditchwitchok.com/custompage.asp?pg=financing.

(2010). Education and Events. On American Rental Association. Retrieved on Oct. 14, 2010, from http://therentalshow.com/EducationandEvents.aspx.

(2010). Equipment World October 2010. On Equipment World. Retrieved on Oct. 19, 2010, from http://www.digitalmagazinetechnology.com/a/?KEY=equipmentworld-10-10october#page=0.

(2010). Groundhog T4 vs. Vermeer RT60. On LawnSite.com™ - Moose River Media. Retrieved on Sept. 27, 2010, from http://www.lawnsite.com/showthread.php?t=170961.

(2010). Industry Links. On Ditch Witch. Retrieved on Oct. 20, 2010, http://ditchwitch.com/resources/industry-links.

(2010). Previous Issues. On Landscape Contractor. Retrieved on Oct. 20, 2010, from http://tinyurl.com/2ebdk2r.

(2010) RT60 Mechanical Mini-Trencher. On Vermeer. Retrieved on Oct. 15 2010, from http://www2.vermeer.com/vermeer/equipment/trenchers/rt60.

(2010). T-4 Trencher. On Ground Hog Inc. Retrieved on Oct. 13, 2010, from http://www.groundhoginc.com/productview.php?iProductID=7.

(2010). Trade Shows. On Association of Equipment Manufacturers. Retrieved on Oct. 19, 2010, from http://www.aem.org/TradeShows/TradeShows/.

(2010). Trencher & Plows. On Ditch Witch. Retrieved on Sept. 17, 2010, from http://ditchwitch.com/trenchers-plows/walk-behind.

(2010). Walk-behind Trencher & Vibratory Plows. On Ditch Witch. Retrieved on Sept. 17, 2010, from http://ditchwitch.com/trenchers-plows/walk-behind.

13. Appendices

13.1 Appendix A – Ground Breakers
13.2 Appendix B – The Charles Machine Works Inc.
13.3 Appendix C – Design Research
13.4 Appendix D – Industry Research
13.5 Appendix E – Market/Campaign Research

DESIGN OF SMALL, WALK-BEHIND TRENCHER

Dec. 9, 2010

Ground Breakers

Lisa Brown · Elizabeth DeKinder

Robert Parrish · Chase Vencl

Mission Statement

Ground Breakers is devoted to exceeding our client's expectations within the marketing, design and profitability aspects of our resourceful products. Our intent is to provide a product promoting the company's growth and development within the competitive marketplace.

The Charles Machine Works Inc.

- Located in Perry, Okla.
- Commonly known for trenchers

Problem Statement

Our objective is to market, design and produce a small, walk-behind trencher with design specifications of:

Specification	Detail
Trenching depth	<20 in.
Trenching width	<3 in.
Weight	180-200 lbs.
Engine size	~5hp
Production costs	<$1,750
Retail price	$2,000-$2,500

Prototype Purposes

- Fencing
- Irrigation
- Other landscaping services
- Electrical lines
  - TV cables
  - Internet cables

Audience

Males between ages of 25-55 in the following industries:

- Rental yards
- Landscaping
- Construction
- Potential for retail/rental in home improvement stores
  - Lowes
  - Home Depot

Competitors

- **Vermeer RT60**
- **Ground Hog T-4**
- E-Z Trench 9100
- Kwik-Trench KT100
- Kwik-Trench KT2400B

Vermeer RT60

Specification	Detail
Trenching depth	12 in.
Trenching width	3 in.
Weight	270 lbs.
Engine	Honda 5.5hp
Trench Type	Chain
Production costs	~$3,200
Retail price	$3,800

http://tinyurl.com/29holjn

Vermeer RT60

http://tinyurl.com/22t85ne

Ground Hog T-4

Specification	Detail
Trenching depth	12 or 18 in.
Trenching width	3 or 4 in.
Weight	230 lbs.
Engine	Honda 5.5hp
Trench Type	Chain
Production costs	~$2,400
Retail price	$3,000

http://tinyurl.com/2g4qnqz

Ground Hog T-4

http://tinyurl.com/2a772h6

Industry Standards

- **Heavy Construction Equipment Rental & Leasing**
- Tools, Equipment & Other Centers in the U.S.
- Land Development in the U.S.
- Single-Family Home Building in the U.S.

IBIS *World* Reports

Safety Regulations

- Kill/stop switch, safety chain guard over the chain boom
- Keep others at least six feet away
- Use personal protective equipment
- Color codes for utility markings
- Use proper tie-downs for transportation

http://ditchwitch.com/safe/

Field Testing

Ground Hog T-4 Disadvantages

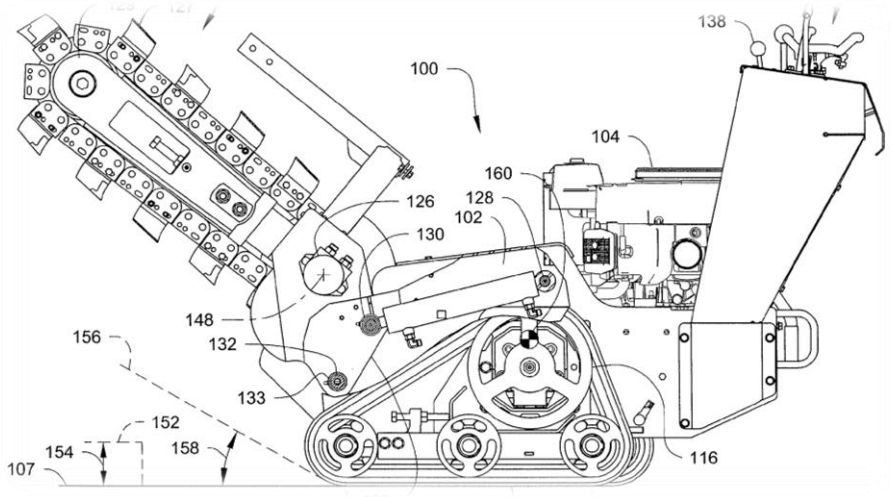
- Hard to maneuver
- No ground-drive assist
- No depth indication on lever
- Emergency shut-off switch needs design improvement

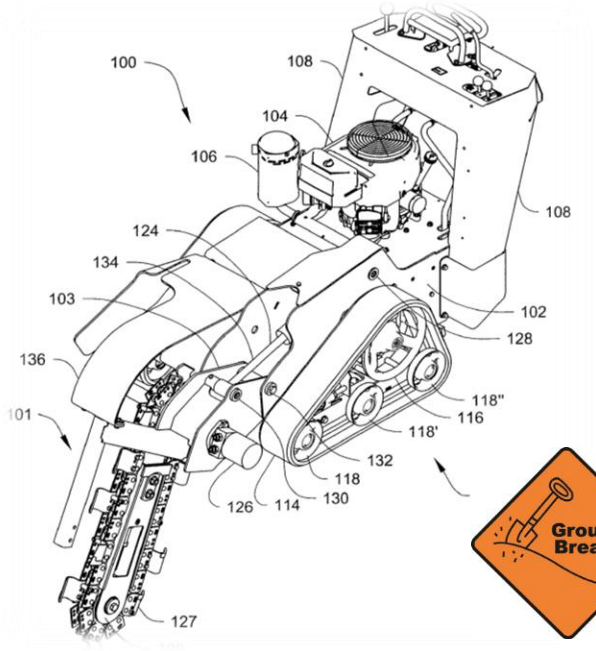
Lisa Brown

Patents

PN 7805864, Walk Behind Trenching Machine

- incorporates a trenching boom with an endless chain, which can be movable between an operating position and a transport position



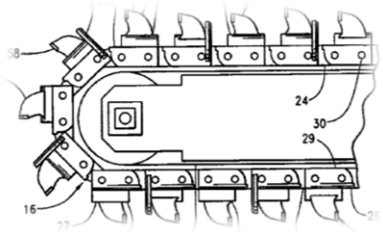


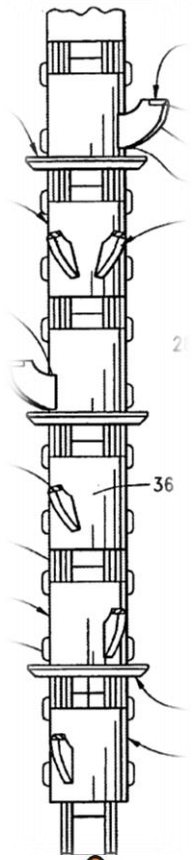
http://tinyurl.com/23cb98u

Patents

PN 6832443, Cutting Chain

- effectively and efficiently drags out soil, broken materials, and other underground materials to the surface providing a much cleaner trench, improving the trenching performance of the cutting chain



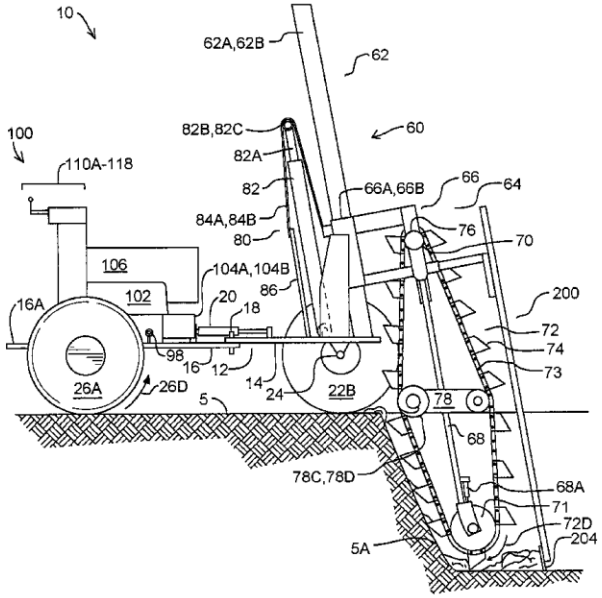


http://tinyurl.com/37penzh

Patents

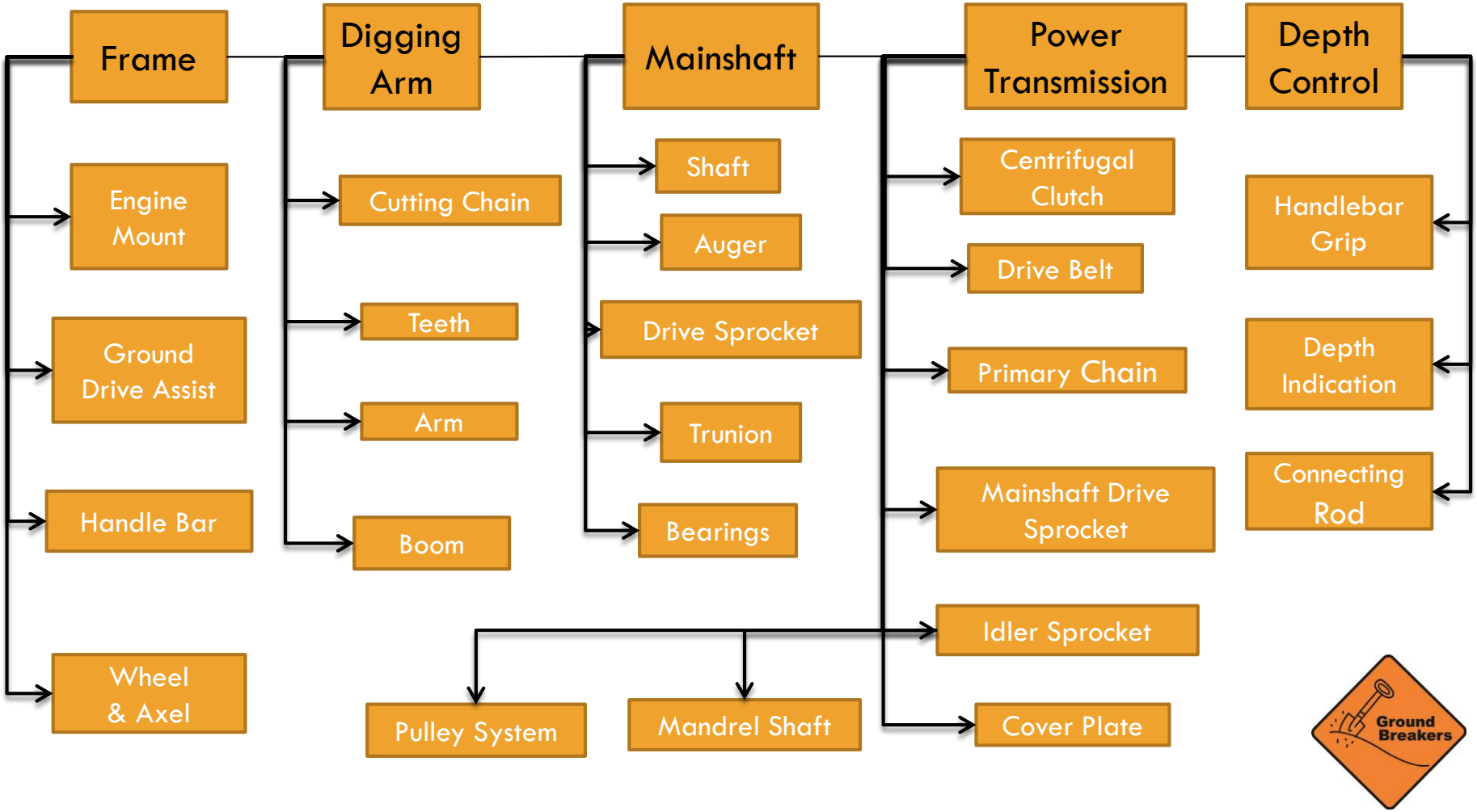
PN 6658768, Trencher

- digs a curved trench and transitions between excavating a straight and curved section of a trench



http://tinyurl.com/2we3eqg

Main Design Components



Design Key Features

- Maximum operating depth at 18"
- <3"trench width
- Ground-drive assist
- Maximum weight 180 lbs.
- Fit in the bed of a truck
- Emergency shut off of chain/engine
  - operator releases handle bar
- Minimal cost

Design Considerations

Motors

- Honda GS190
  - 5.2hp
  - 30.4 lbs.

- Briggs and Stratton 800 Series
  - 5.5hp
  - 32.7 lbs.

http://tinyurl.com/35moxot
http://tinyurl.com/29tmbfr

Ground Breakers

Design Considerations

Ground-drive Assist

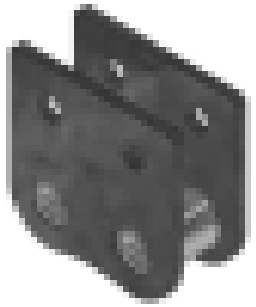
- Not a necessity
- Included in design to meet consumers' requests
- Consumers are willing to pay extra to have it
- Allows smoother trenching
- Makes trenching easier

http://tinyurl.com/3y72vdz

Design Considerations

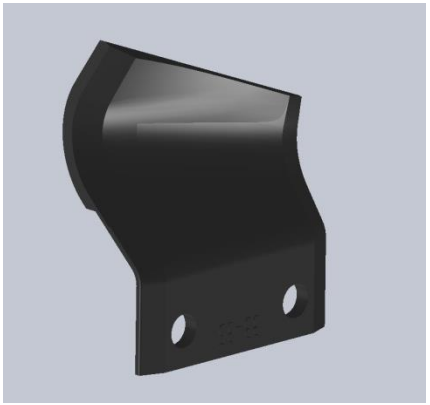
Cutting Chain: Drives LLC.

- WSK-2 Roller Link
  - 2" pitch
  - $118.47



Cutting Tooth:

- Side bolt attachment
- Manufactured by Ditch Witch



http://tinyurl.com/2ul5aat

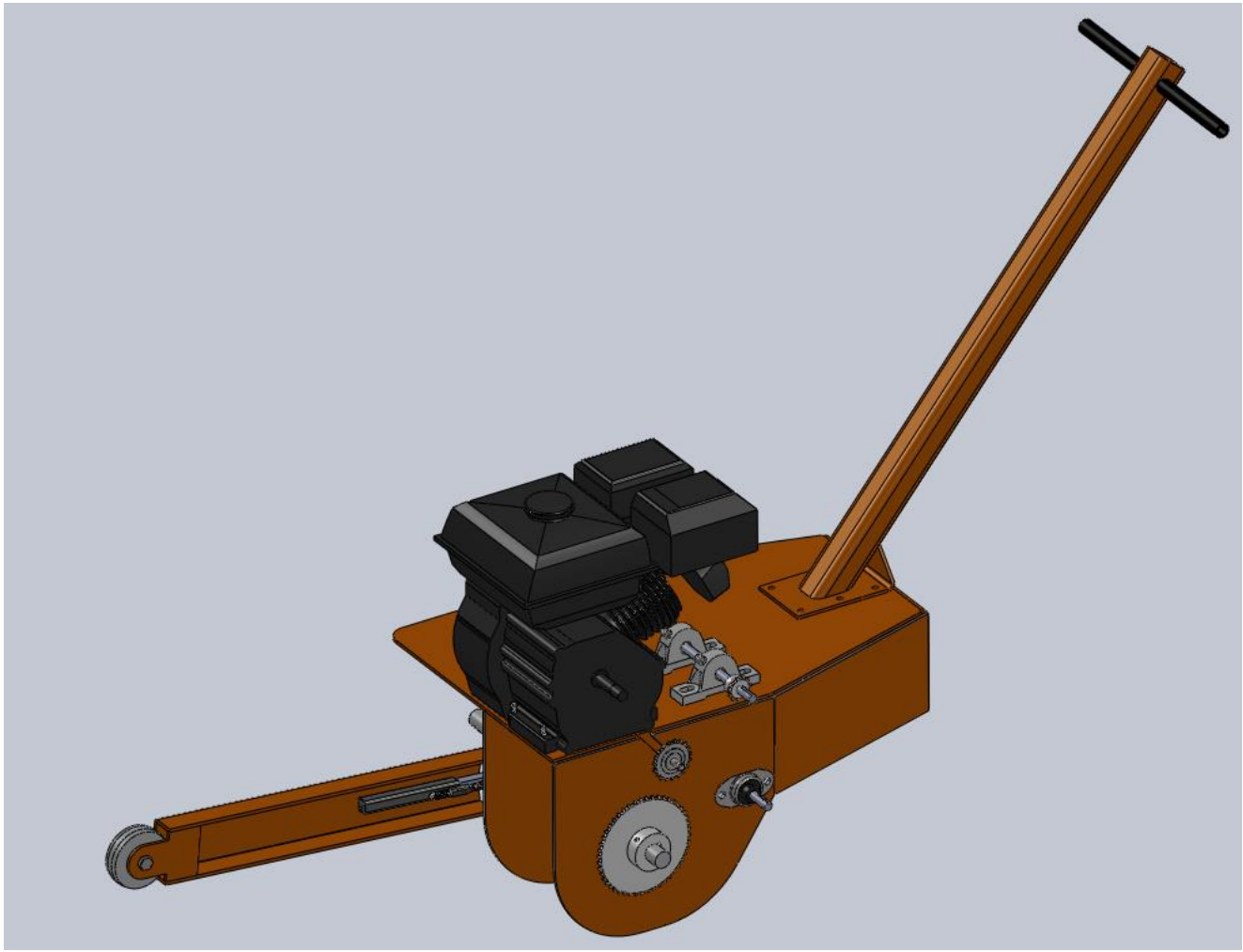
Design Considerations

Possible Trench Teeth Designs

- Ditch Witch Shark Chain II
  - effective in hard soil
- Ditch Witch 2 Pitch Cup
  - effective in hard soil
- Ballantine Terminator®/Cup combination Chain Assembly
  - effective in hard soil

http://tinyurl.com/39rvq74
http://tinyurl.com/2vshfqk

Prototype Design



Prototype Design

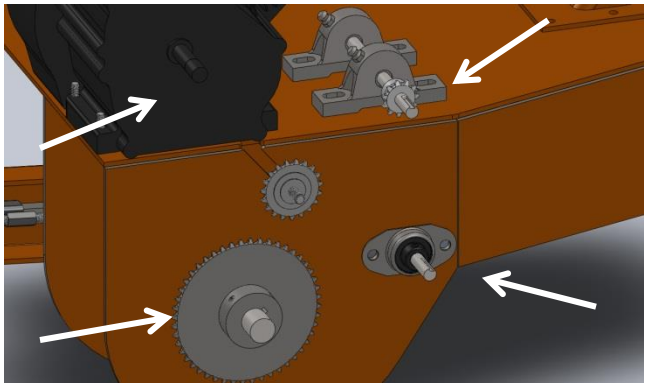
Proposed Design

Frame

- Gauge 7 sheet metal (3/16”)
  - Small size to reduce storage space needed
  - Minimal weight
  - Sufficient material for strength and stability

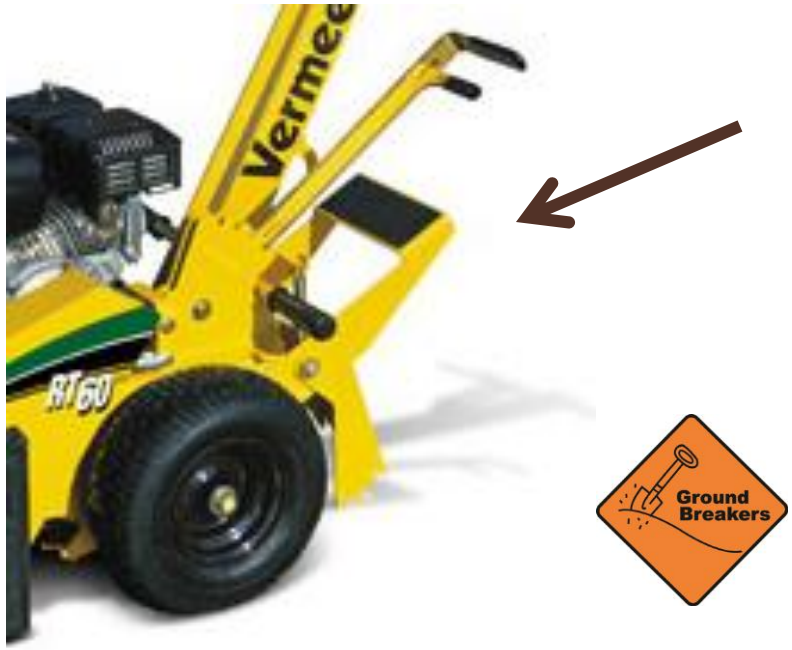
Proposed Design

Power Transmission



- Mechanical friction clutch connected by a v-belt to a sheave with a small chain sprocket

- Ground-drive assist with planetary gear train to reduce speed for wheel shaft to less than 2 rpm



Proposed Design

Ground-drive Assist

Dynacorp
Clutches and Brakes

- Spring Clutch attached to wheel axle to allow axle lock during operation and free rotation for transportation
- Spring Clutch can be controlled from the handle bar

http://tinyurl.com/24xqhk6

Ground Breakers

Prototype Design - Explanations

Shaft Size Determination

- Main shaft:
  - 1" diameter
- Mandrel shaft:
  - 1/2" diameter

Chain Sprocket/Main Shaft

- ~380 rpm
- speed reduction 9.5:1
  - sheaves
  - sprockets

Production Cost Estimates

Product	Product Specification	Quantity	Price
Engine	Honda GS190	1	$ 294.00
Clutches	spring clutch	2	$ 140.00
	sheave clutch	1	$ 90.00
Steel Shaft	20" of 1" diameter	1	$$$
	10" of 0.5" diameter	1	$$$
Planetary Gear Train		1	$ 300.00
Sprockets	11T, 45T, 19T		$ 40.00

Production Cost Estimates

Product	Product Specification	Quantity	Price
Sheet Metal	~1500 sq. in. (Gauge 7)	1	$$$
Bolts/Nuts			$ 50.00
Sheaves	2-9" Sheaves, 2 belts		$ 42.00
Bearings	2 tapered, 2 flange, 2 base, 1 ball		$ 55.00

Production Cost Estimates

Product	Product Specification	Quantity	Price
Chain	2080H	1	$120.00
Digging Teeth	Teeth	70	$50.00
Wheels		2	$80.00
Labor	Spring 2011	2	$$$
	Est. Production Costs		$1,311.00
	Specified Cost Constraint		$1,750.00

Business Plan

- Manufacturing:
  - DW's headquarters in Perry, Okla.
- Outsource:
    - chain, bearings, belts and sheaves
- Teeth design from DW products

Planned Campaign Strategies

- Product launch video
- Web page for Ditch Witch website
- Trade publications advertisements

Planned Campaign Strategies

- Trade show materials (folder)
  - Spec sheets
  - Quote sheets
  - Performance rating brochure
    - Product testing results
  - Business cards

Schedule

Date	Task	Deliver to:
January 2011	Obtain materials to begin prototype construction	Ditch Witch
March 11, 2011	Complete construction/building of prototype	Ground Breakers
April 1, 2011	Complete testing and repairs Begin marketing/campaigning strategies	Ground Breakers
April 28-29, 2011	Final presentations	Ditch Witch
May 6, 2011 (nlt)	Deliver prototype, final report and campaigning materials	Ditch Witch

DESIGN OF SMALL, WALK-BEHIND TRENCHER

Dec. 9, 2010