Design Team:

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Mission Statement

Our mission is to provide innovative and economical solutions to the hay and forage industry that will maximize efficiency.

Table of Contents

Introduction

After the first semester, it was decided that instead of making a prototype, we would make a full scale mock up. The purpose of this mock up is to determine if using rollers in the floor of our quarter turner will make a big enough difference in increasing the ease of sliding the bales that the required output for the hydraulic system is lowered enough to make our quarter turner cheaper to build.

Problem Statement

Our team was faced with the task of designing an attachment that would rotate large square bales ninety degrees along the long axis of the bales. This has to be done before the bale is on the ground. The bale size we are focusing on is 3x4x9 feet.

Statement of Work

The purpose of this attachment is to alter the placement of the bale after is has been ejected from the baler and before it hits the ground. The final placement of the bales is to be ninety degrees from its original orientation when leaving the baler. The design of this attachment will also focus on minimizing the dragging of the bales on the ground and therefore reducing soil accumulation on the bales. The designing of this attachment and its options started in September and should be completed by December 7th, 2012. The making of the mock up began January 14th, 2013 and ran through April 19th, 2013. Our deliverables are a schedule of events, a completed design, a completed mock up, and results of testing. The time schedule on our deliverables will end on May 1st, 2013. The acceptance criteria for this attachment is if the

bale is turned ninety degrees before it gets to the ground and that there is no more than four inches of sliding once on the ground.

Work Breakdown Structure

The Large Square Bale Quarter Turner is broken down into four parts: documentation, design, testing, and fabrication. Documentation includes patent searches, market research, competitive analysis, and any other research that needs to be done. After documentation comes design. Design is broken down into five parts: Connection Mechanism, Axle Component, Frame, Hydraulic/Power System, and Turning Mechanism. The Connection Mechanism or hitch is based off of a similar style that AGCO already uses. The Axle Component is broken down into Chassis and Tires. Chassis deals with how the attachment is supported. Some options were using an axle, caster wheels, or a walking axle with caster wheels. It was decided to go with caster wheels because they allow for easier turning. Tires include the size and number of tires. Two tires on each caster with two casters to support the weight is what the final decision was. For the Turning Mechanism there were options for rollers, gravity drive, and a swing arm. It ended up being a combination of a gravity drive and swing arm where the swing arm is what turns the bale and gravity makes it slide to the ground. The swing arm will turn the bale ninety degrees. After this happens, the bale will only be sitting on 1.5 feet of the frame where it will tip and slide down a slide that is angled towards the ground. Testing is the next step. Once there is a working mock up there can be more testing performed to identify any problems that may arise during operation. Lastly is fabrication. This deals with taking the design and making a mock up once it has been determined which one will be built.

Task List

From the beginning, the tasks include finalizing plans; making a schedule; determining materials to be used and costs; creating computer drawings; determining whether or not to make a working model, a prototype, or both; analyzing loads. The schedule will be a Gantt chart that can be found in Appendix A. The materials and costs associated with them can be found in Table 1 on page 14. A list of all tables and figures can be found in Appendix D and E. As for testing, all of it was conducted after the fabrication of the mock up was completed.

Analysis and Research

Competitive Analysis

Competition in the hay and forage industry is low, with the three largest players Deere & Company, CNH Global NV and AGCO Corporation; all three accounting for more than half of all industry revenue. These large, diversified companies are "price makers" within the industry; therefore, price-based competition between them is low. Instead, the industry's leading firms primarily compete on product quality, performance and innovation; efficient production and distribution arrangements; customer service; and the establishment of brand names. There are no licensing requirements, government regulations or resource constraints that are significant enough to prevent firms from entering the industry (IBIS*World*, 2012).

“The acquisition of manufacturing facilities fitted with the equipment required to manufacture agricultural equipment requires a large capital investment. The magnitude of this financial commitment deters some firms from entering the industry. There is also a medium

concentration of firms within this industry, giving them the ability to exercise a high degree of market power." According to the industry report, "The cost of entering and competing with incumbent firms that have strong relationships in downstream markets and long histories may also deter some firms from entering" (IBIS*World*, 2012).

Market Research

Major players in the marketplace include AGCO Corp., Claas KGaA mbH, CNH Global NV, Deere & Company (John Deere), Escorts Group, Iseki & Co. Ltd., Kubota Corp., Kuhn Group, Kverneland ASA, Mahindra Group, Same Deutz-Fahr Group, and Tractors and Farm Equipment Ltd. (Western Farm Press, 2011). With over 1,000 enterprises operating in this industry, the top-two companies, Deere & Company and CNH Global NV generate about 55.8% of all revenue for agricultural machinery (IBIS*World*, 2012). How much of this revenue is from the sales of haying equipment and attachments is unknown. A high level of research and development, large economies of scale, extensive dealer networks and longstanding reputations make it difficult for new players to compete with the major operators.

"Deere & Company is the world's leading manufacturer of agricultural and forestry equipment with a market share of 44.2%. While severe summer drought conditions in the Midwest took a heavy toll on the nation's crops in 2012, record commodity prices and the widespread use of crop insurance in the United States are expected to protect and even boost farmers' incomes, contributing to an increase in demand for agricultural equipment. On the back of this strong demand, revenue from Deere's industry-relevant operations is expected to increase 2.6%."

(IBIS*World*, 2012)

Also included in the industry report:

"CNH Global NV is the world's second-largest manufacturer of agricultural equipment with a market share of 11.6%. CNH sells these products through 12,000 dealers and distributors in 160 countries. The company also services a worldwide net managed portfolio of more than $18.0 billion, helping with dealer and customer equipment financing throughout North America, Latin America and Australia. CNH has a significant global presence: about 38.0% of the company's revenue comes from North America, 33.0% from Western Europe, 12.0% from Latin America and 18.0% from the rest of the world. North America equipment operations encompass operations in Canada, the United States and Mexico, with an estimated 64.0% of North America agricultural equipment revenue coming solely from operations within the United States."

(IBIS*World*, 2012)

Current hay and forage equipment market share for Deere & Company, CNH and AGCO are unknown at this time.

Patent Search

There are two patents that are relative to this project because they are solutions to the exact same problem that was presented. One is the Jumbo Bale Rotating Table for a Hay Baler and the other is the Bale Turning Apparatus. Denzel R. Finney and Kelly D. Finney, of Fort Sumner, New Mexico, hold the patent for the Jumbo Bale Rotating Table for a Hay Baler. The patent number is 5560191 and was filed on June 5, 1995. The U.S. classification is 56/474; 100/45; 100/179; 100/188.00R; 414/744.7; 414/779. For the Bale Turning Apparatus, Richard L. Simon of Wichita, Kansas is the inventor, but Maize Corporation out of Maize, Kansas, holds the patent. The patent number is 6033172 and was filed on February 19, 1999. In the U.S., the classification is 414/24.5; 414/482; 414/483; 414/911. The first patent found was the Jumbo Bale Rotating Table for a Hay Baler. This patent produced an idea of using a turntable, but making it a trailer like attachment instead of one supported by the frame. Further patent searching uncovered the Bale Turning Apparatus. The original idea of a turntable was thrown

out after finding this patent due to the fact that the idea was very similar to the already existing patent. From these patents, the choice was made to stick with the original trailer like attachment but instead of a turntable, using a swing arm to push the bale around ninety degrees. These patents can be seen in Appendix B and Appendix C.

Impacts

There are some possible societal impacts that could stem from using this device. The largest impact would be the increase in efficiency and time saved. Even though it does not seem like it would save much time, it begins to add up with each bale and the time savings is noticed when pulling out of the field. Not only is time saved, but also in theory, fuel consumption can be lowered. Instead of driving through a hay field having to swerve to pick up bales, a person can follow the windrows through the field taking the same path as the tractor and baler. This is a more direct path to pick up the bales and therefore shorter. This means that the productivity of the machine used to pick up the bales goes up due to the fact that it could pick up more bales in the same amount of time when compared to not using a bale quarter turner behind a baler.

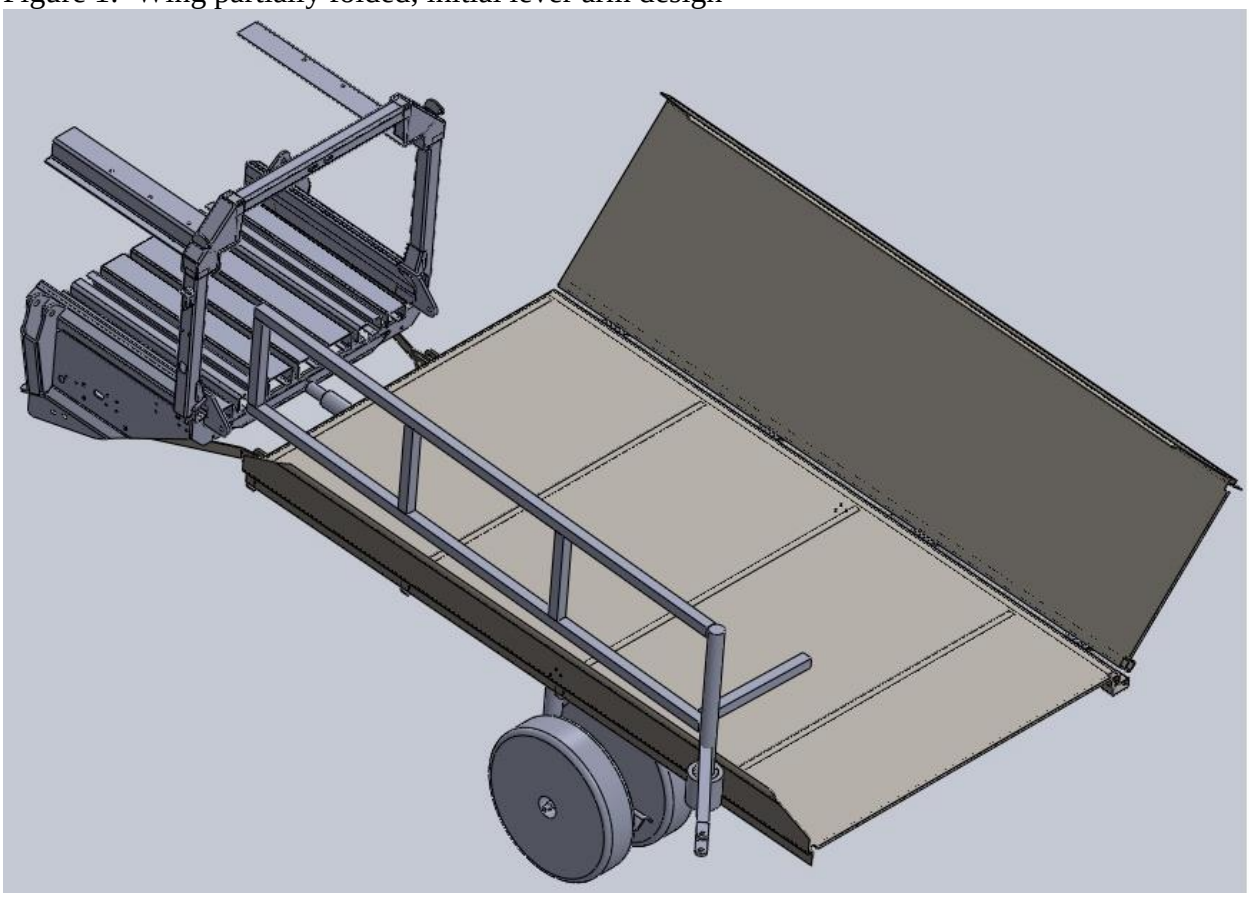
Customer Requirements

AGCO wanted an attachment designed that turns a large square bale ninety degreed on its longitudinal axis from the original orientation out of the baler. They wanted to minimize the cycle time or at least justify it to make sure it can run as fast as the baler can produce bales. The retail price of this attachment is to be approximately $15,000 or lower if at all possible. AGCO wants the design of this attachment to be as simple as possible.

Engineering Specifications

The quarter turner attachment will be a pull type attachment instead of an attachment that connects to the frame and doesn't have wheels and tires. The largest bale size that the attachment can handle will be 4x4x9 feet. It will have a frame that the bale slides on to that measures 10x10.5 feet. The width of ten feet was determined by finding the diagonal length of the bale. The Pythagorean theorem for right triangles was used to find this diagonal length, using bales that are four feet wide and nine feet long, of 9.85 feet. Ten feet was chosen for the width to allow for some clearance so the bales do not get stuck while turning. Realizing that .15 feet is more than likely not enough clearance, the frame will more than likely be widened to 10.5 feet. This can only be determined though through testing which will come next semester. This frame is made out of 2x4 steel tubing that is 3/16 inch thick and 3/16 inch sheet metal. These sizes and thicknesses were determined by estimations that came from looking at AGCO accumulators. Further testing will determine whether or not smaller or larger sizes will be needed based on the design factor that we choose of ten. This design factor was chosen in order to better ensure that the quarter turner would not break under negligent conditions like hitting trees or other machinery. This frame will have one side that folds up using a hydraulic cylinder. This side that folds will be three feet wide and have a cylinder with a twenty-inch stroke and overall length of forty-eight inches. The column load for this cylinder is 7930 pounds (SOURCE: Bailey). Below is a figure of the quarter turner with the wing partially folded up.

Figure 1: Wing partially folded, initial lever arm design



Two casters will be used to support the weight of the quarter turner and the bale. Each caster will have two tires, one on either side of each caster. Each of theses tires it rated for 1610 pounds at forty miles per hour. The size of these tires is 6.70-15SL (SOURCE: Pete's Tire Barn). There will be a swing arm along the left side of the frame. This arm will pivot two feet from the back end of the frame. The arm will made of 2x2 inch tubing that is 3/16 inch thick. It will pivot around a tow-inch solid steel rod. There are two rails on the arm that are 1.5 feet apart and nine feet long. It is these rails that will actually come into contact with the bales and swing them around. These rails have three vertical supports between them that are spaced three feet

apart down the length of the two rails. A hydraulic cylinder moves the swing arm. This cylinder has a forty-four inch retracted length with a thirty-six inch stroke making its total extended length eighty inches. Also, it has a 2-inch bore with a 1.25-inch rod diameter and is capable of handling 4120 pounds as its column load (SOURCE: Bailey). This cylinder was chosen because it was calculated, using a static friction coefficient of .71 (SOURCE: Di Cristoforo & Sweatman, 2004) and a maximum bale weight of 3000 pounds, that the force to push the bale across the steel plate is 2130 pounds.

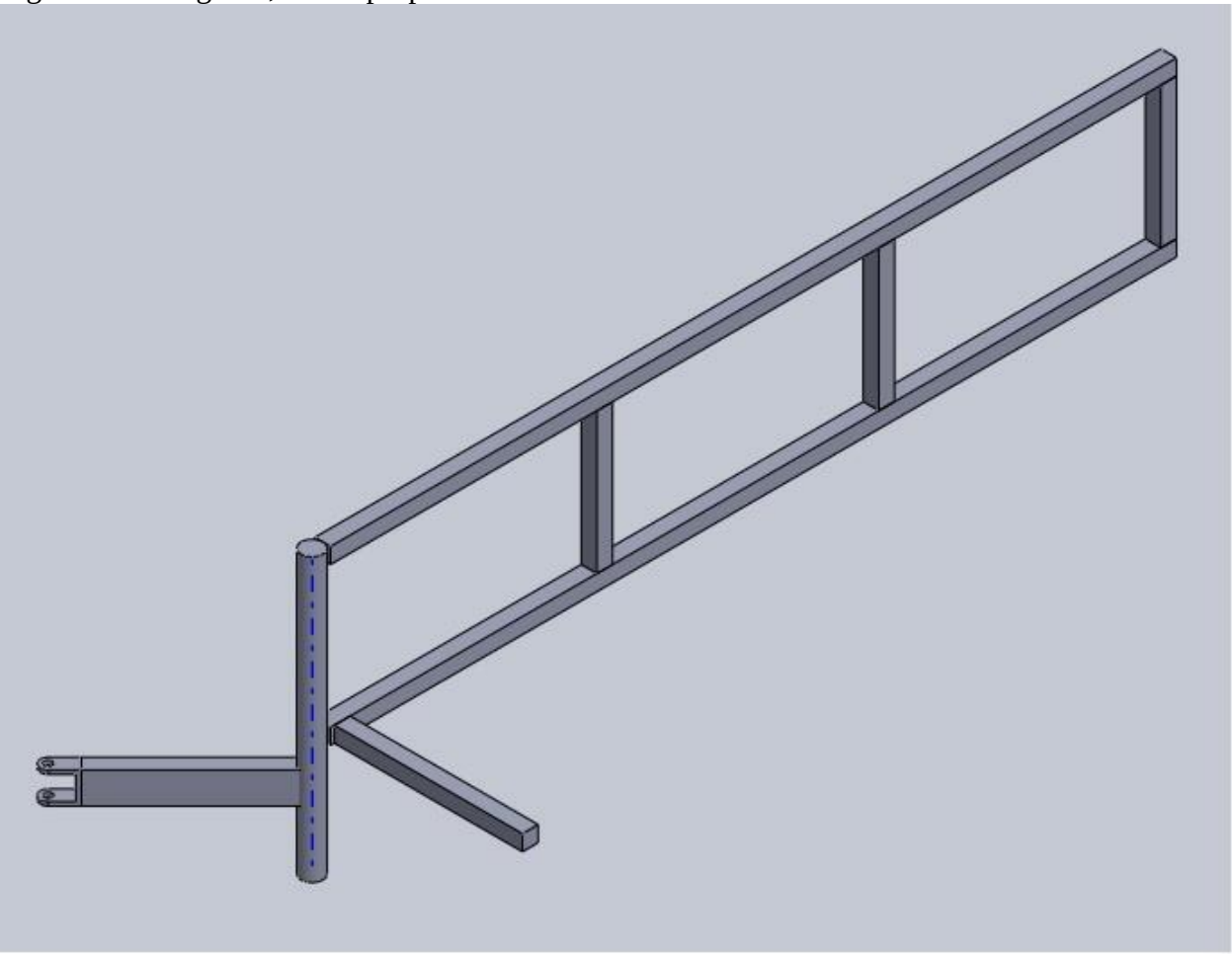
$$.71 * 3000\ lb = 2130\ lb$$

Since the cylinder is not acting on the bale directly, and instead is pulling on a beam attached to the swing arm pivot at a forty-five degree angle, the maximum force from the cylinder exerts on the bales is 4406 pounds.

$$4120\ lb * \sin 45° = 2913\ lb$$

4120 pounds is the maximum weight that the cylinder can handle. This cylinder will be attached to the frame by the same 2x4 tubing that helps support the steel plate. The cylinder will be offset from the frame by 1.4 feet. This offset was determined by taking the square root of two since the beam that the opposite end of the cylinder is attached to is two feet long and positioned at forty-five degrees. The swing arm can be seen on the next page in Figure 2.

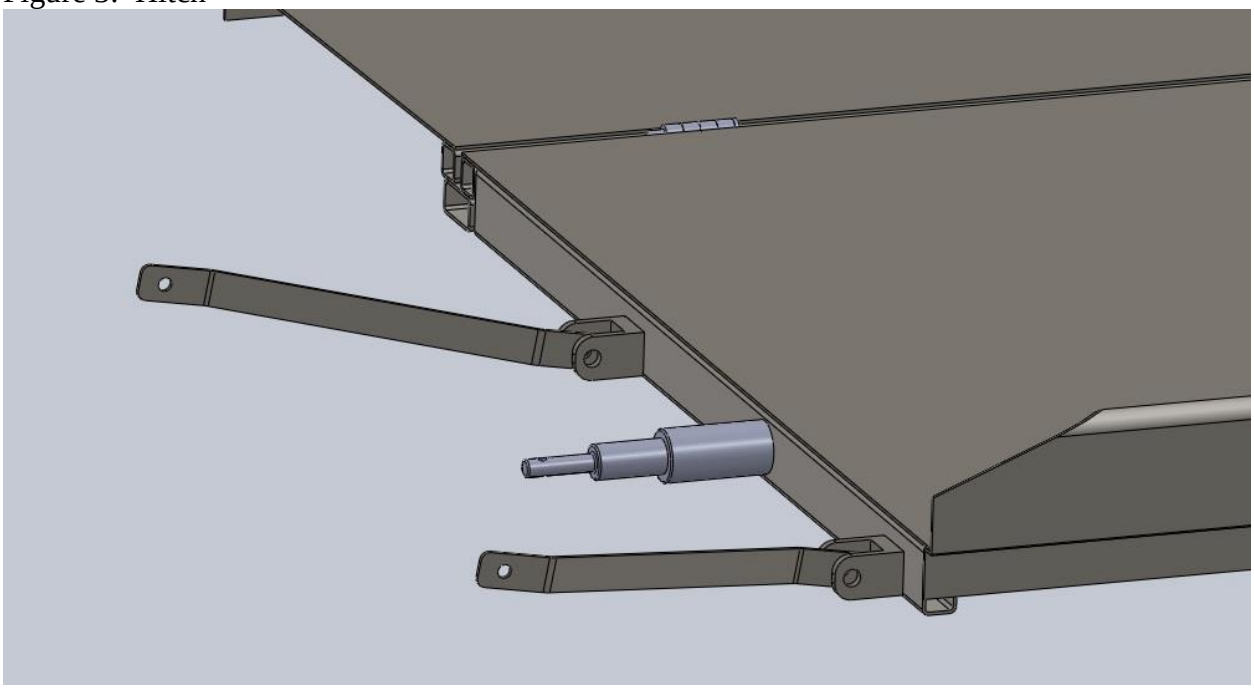
Figure 2: Swing arm, initial proposal



The quarter turner and bale weight will be supported by two caster wheels. The tires are rated for 1610 pounds apiece (SOURCE: Pete's Tire Barn) and the estimated maximum weight of the quarter turner with a three thousand pound bale on it is 5000 pounds. This was estimated by looking up the weights of the materials and multiplying that by the amount of each material that was used. Since some of the weight will be on the hitch, the tires do not have to endure the full five thousand pound load. Therefore, 4 tires rated at 1610 pounds will be able to carry the weight. On the back of the frame that the bale sets on, there will be an extension that the bale will slide down before it hits the ground.

This extension will allow the bales to be one foot off the ground before they drop off the quarter turner. This height was determined by looking at the pick up attachment on the baler. It was estimated that the attachment could not rise any higher than one foot. From this estimate, the minimum height of the end of the slide was determined. The hitch that attaches the quarter turner to the baler will have two ways in which it can move so that the quarter turner can follow behind the baler on a wider range of terrains without breaking the hitch. It will be able to pivot almost like a hinge to allow the quarter turner to go over hills. There are also two side supports that let the quarter turner twist and still remain attached to the baler. This allows the quarter turner to lean left and right, as the baler is taken sideways across slopes in the landscape. The hitch can be seen below in Figure 3.

Figure 3: Hitch



Financial Analysis

The overall cost for the mock up that was built was $880.19 as can be seen in Table 1 below. The bearings and rollers were given to us by AGCO and the hydraulic hoses were fabricated and donated by Independent Diesel out of Enid, OK.

Table 1: Cost of mock up

Budget for Mockup	
Item	**Cost**
2x2x3/16 in steel tubing	
2x4x3/16 in steel tubing	
3/16 steel sheet	$699.19
2 in solid steel round	
4 in sch 40 steel pipe	
6 in C-channel	
ball bearing	donated
retainer ring	$7.00
36 in stroke hydraulic cylinder	$174.00
hydraulic hoses and fittings	donated
rollers	donated
TOTAL	$880.19

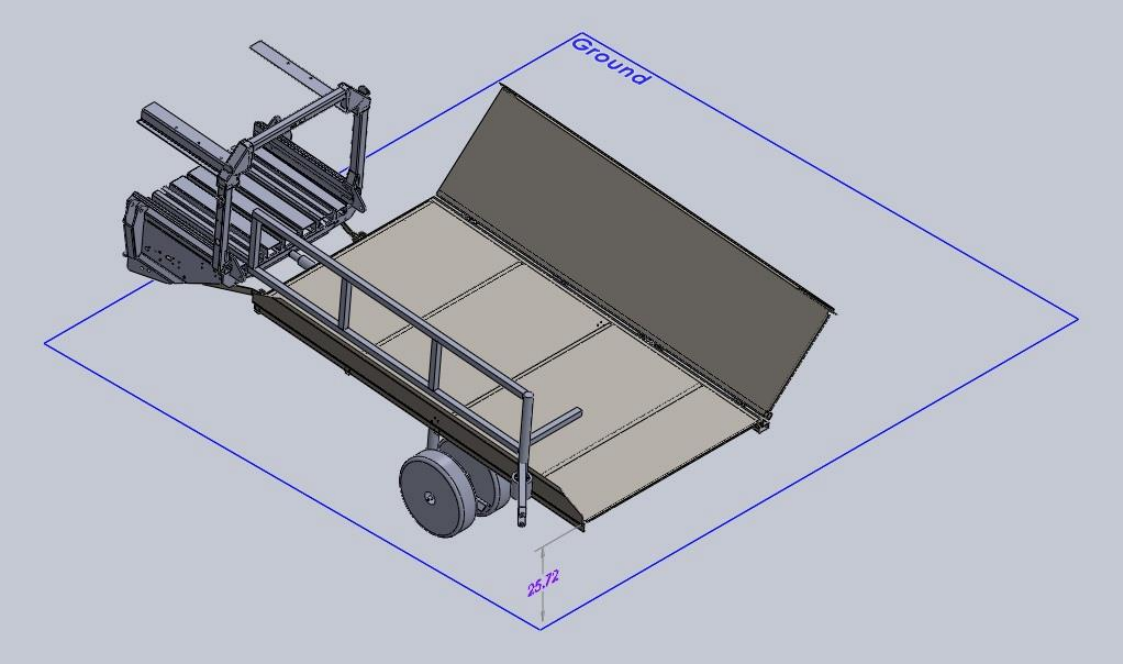
Design Concepts

For the hitch, it was known that it had to be made flexible so it wouldn't break when the baler and quarter turner aren't perfectly in line with each other. It will be able to pivot for going up and down hills as well as tilt from side to side. If the hitch of the quarter turner were to be made to where it could not move or be flexible then the quarter turner would come off the ground when going over the top of a hill and would get twisted and break when going over uneven terrain. To prevent this, the hitch would have to be much stronger and it would have

increased our costs dramatically. This is why the choice was made to go with a flexible hitch. The main solution for actually turning the bale will use a hydraulic cylinder to pull an arm around that will turn the bale. A hydraulic motor was looked into to rotate the shaft that the arm is mounted to but it was determined that the cost of using a hydraulic motor is greater than using a hydraulic cylinder. This is what encouraged the use of a cylinder. The swing arm will stop and return to its original position once the bale reaches ninety degrees from its original orientation. This will be done by using limit switches that will trip pilots that control valves that restrict the flow of hydraulic fluid. Two limit switches will be used. One will be located on the back of the swing arm 1.5 feet from the pivot along the beam that stops the bales from sliding off before they are turned. The other limit switch will be located on the end of the slide. This is so the bales have time to slide out of the way of the arm before it returns to its original position. All of our options will use caster wheels to help support some of the load of the bale and quarter turner. Using a walking beam axle was considered to compensate for the twisting of the quarter turner as it goes over uneven terrain. This was thrown out after we designed our hitch and determined that the walking beam wasn't needed. Also, the walking beam would have made our quarter turner taller and if gravity is to be used, then the frame has to be sloped for the bales to slide back. Using casters allows for a shorter design. The main materials we will use are 2x2 and 2x4 steel tubing, both 3/16 of an inch thick, and steel sheet metal that is also 3/16 of an inch thick. These sizes and thicknesses are estimations from looking at large square bale accumulators. Since our design is similar to an accumulator it is appropriate that we use materials that an accumulator would have in its construction. Since we are only handling one large square bale at a time instead of three like the accumulator, it was assumed that the quarter

turner would have the same or higher safety factor since the same materials are being used in both the accumulator and quarter turner. Further testing and calculations will determine what the actual safety factor of the quarter turner will be. The quarter turner is split into two sections. The left side is seven feet wide and has the swing arm attached to it, whereas the right side is three feet wide and will be able to fold up. This is to allow for easier transportation while the quarter turner is being pulled behind the baler. The right side will fold up using a hydraulic cylinder. The cylinder will have a twenty-inch stroke and an overall length of forty-eight inches. The calculations as for why this cylinder was chosen can be found in the Engineering Specifications section. On the next page, in Figure 4, is the proposed quarter turner.

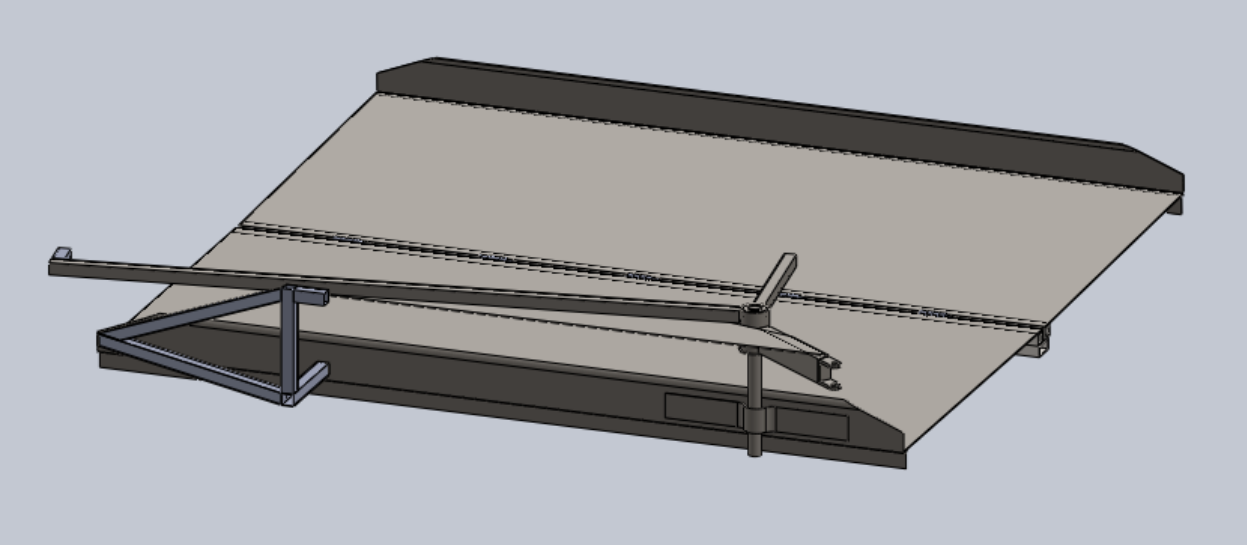
Figure 4: Proposed quarter turner



Design and Fabrication of Mockup

The mock up that is proposed is basic compared to the proposed prototype. It includes only the floor of the quarter turner and the swing arm. See Figure 5 below.

Figure 5: Quarter Turner Mockup, cylinder not installed



For testing, the assembly sits on the ground. It was made in two parts, which can be seen on the next page in Figures 6 and 7, to make it easier to move around in the shop. Holes in the C-channel were added so a forklift could be used to move it. Ratchet hooks were added to the sides in order for an overhead hoist to be used in moving it also. Bales are placed on the mock up and then a hydraulic cylinder is used to move the swing arm and slide the bales. The cylinder is not shown in the above figure.

Figure 6: Side 1, it has the pivot for the swing arm and the brace for cylinder

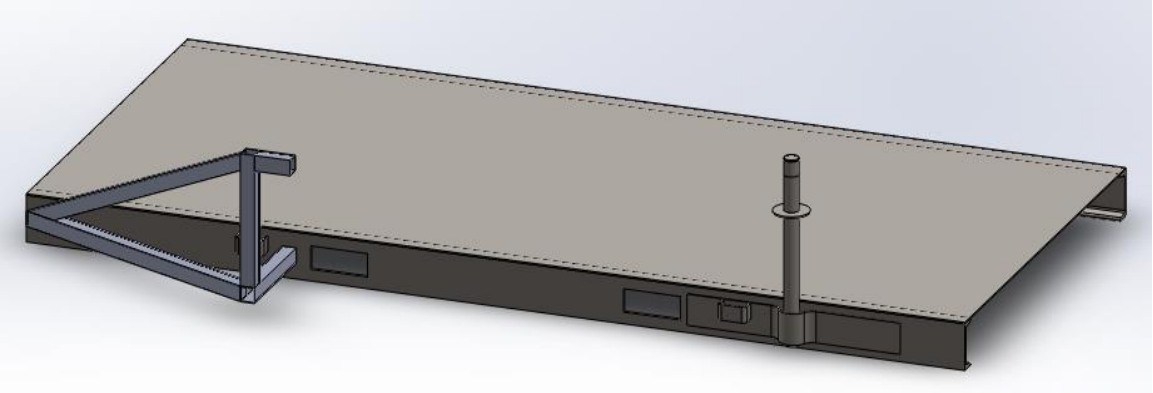
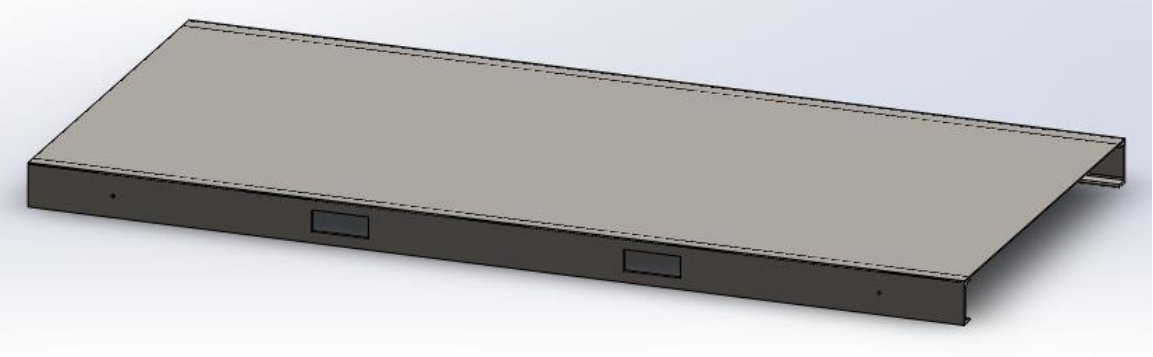


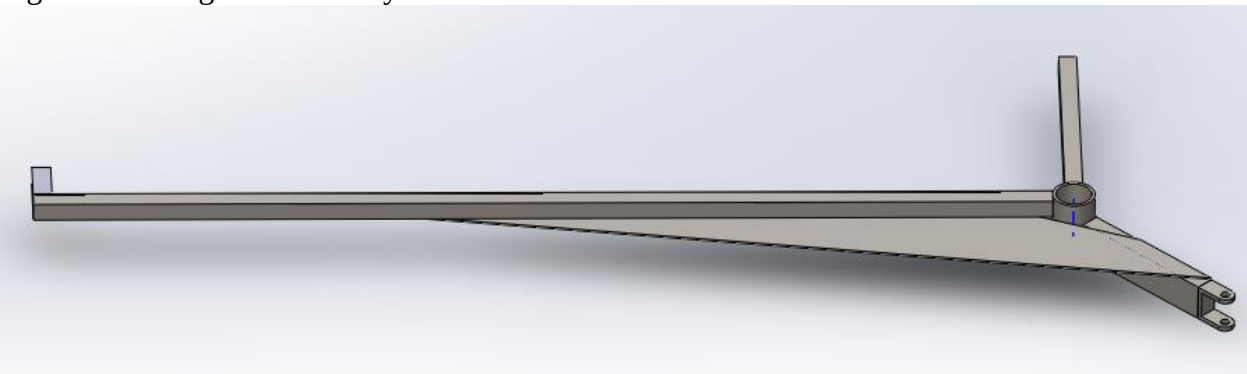
Figure 7: Side 2



The floor of the mockup measures 10 feet wide by 11 feet long. It is made of 7 gauge steel sheets and 6 inch C- channel. The two sides are bolted in the middle during testing. The pivot for the swing arm is 2 inch solid steel rod. It has a round plate welded to it 10 inches above the floor for the swing arm to rest on. There are also two groves towards the top of the rod for retainer rings to hold the top bearing in place. The swing arm, seen in Figure 8 on the next page, is made of a 6.75 inch piece of schedule 40 steel pipe for the middle. Welded to that is a 9 foot piece of 2x2 inch steel tubing, a 3 foot piece of 2x2 inch steel tubing, and a 22 inch piece of 2x4 inch steel tubing. In between the 9 foot piece and the 2x4 tubing is a brace that is made of the same 7 gauge steel sheeting that is on the floor. The 2x4 tubing is set at a 135 degree angle from

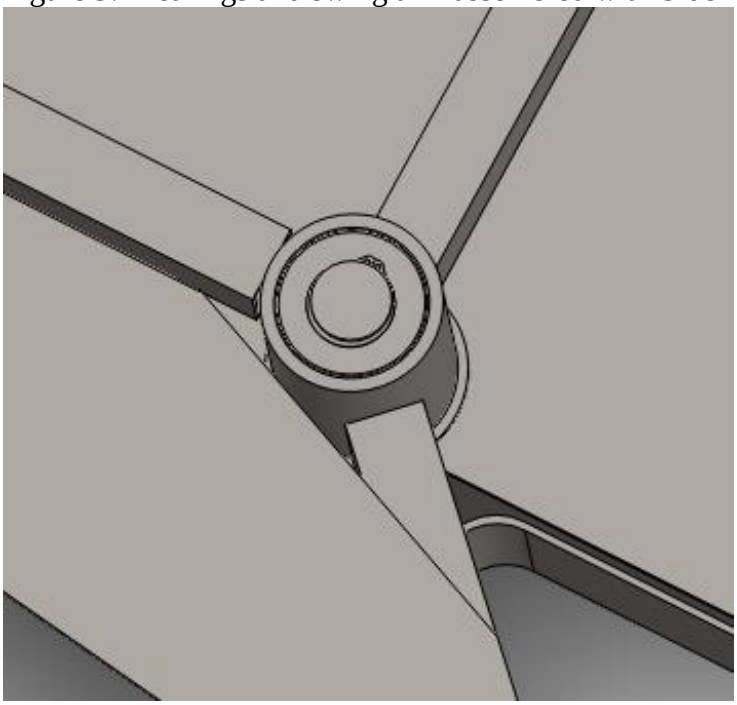
the other two pieces of tubing that are welded on the swing arm. This is so the hydraulic cylinder will be able to have leverage on the swing arm for the full 90 degrees that it has to turn the bale.

Figure 8: Swing arm assembly



Below, in Figure 9, the top bearing as well as the top retainer ring can be seen. This is just to give a view of how the swing arm is placed onto Side 1.

Figure 9: Bearings and swing arm assembled with Side 1



Testing

For the tests performed, a mixed grass hay bale was used. It was weighed using a set of vehicle scales and the weight was determined to be 1284 pounds. The first round of testing was done with just the sheet metal floor on the mock up. For the second round, a section of sheet metal was cut out of the floor and a frame of rollers was dropped into the hole. Initially, the static coefficient of friction needed to be determined between the mock up floor and the bale. A simple test was done to find this. With the bale on the mock up, one end of the mock up was lifted until the bale just started to slide. Then the angle was measured. Using the known weight of the bale and the angle at which it started to slide, the static coefficient of friction was determined using these three equations shown below.

$$F_f = mgsin\theta \qquad F_n = mgcos\theta \qquad \mu = \frac{F_f}{F_n}$$

For the first round tests, with sheet metal only on the floor of the mock up, the static friction coefficient was found to be .29. In the second round tests, apparent friction was cut in half to .14. The term, apparent friction, is used because since the bale doesn't actually slide across the rollers, the rollers move with the bale, the friction between the rollers and the bale is so small that is can be assumed to be zero. The bale still slides across sheet metal though even with the rollers in place. The friction coefficient doesn't change between the bale and the sheet metal since friction is a material property. This is why the term "apparent friction" is used.

The force needed to overcome static friction was determined in two ways. The first way was by watching a pressure gauge and noting the pressure at the moment that the bale just started

to move. This gave a reading of about 800 psi with just the sheet metal and about 400 psi with the rollers. The second way was through calculations using the friction coefficients that were previously found. For the sheet metal only, the force needed to overcome static friction was found to be 372 pounds. With the cylinder having a 2 inch bore and a 1.25 inch rod this gave a pressure of 712 psi in the cylinder. When the rollers were used, the force need to overcome friction lowered to 180 pounds, which comes out to 345 psi in the cylinder. These forces were found by multiplying the appropriate friction coefficient that was found by the weight of the bale. As for the pressures, they were found by multiplying the area of the rod end of the cylinder by the force. The pressure that was noted from the gauge while performing the tests is relatively close to the pressure that was calculated.

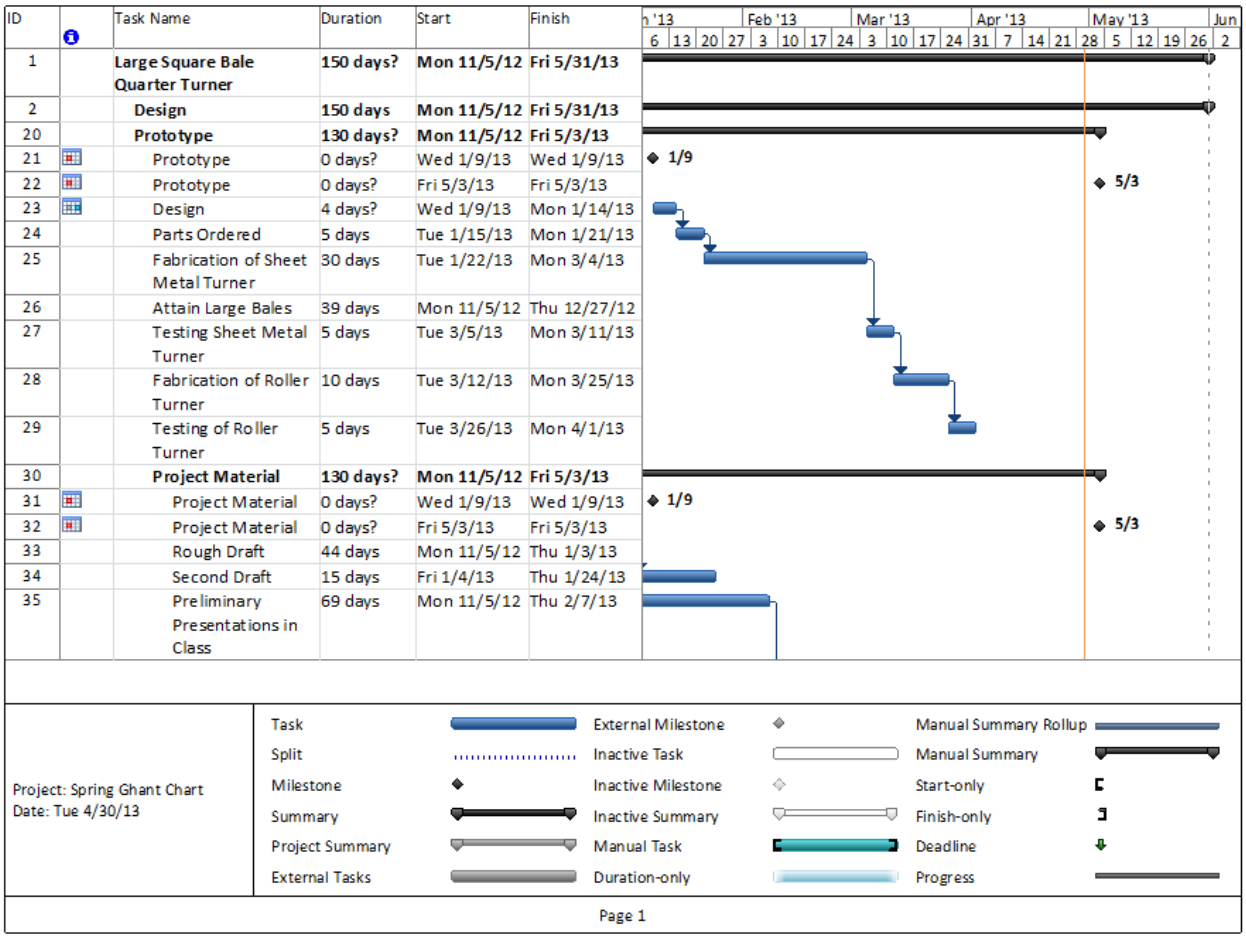
Recommendations

From the results of the tests that were run, it is recommended to just use sheet metal instead of rollers for the floor of the quarter turner. This decision was made because even though the rollers reduce the force needed by half, the sheet metal is slick enough justify not using rollers. Also, as far as maintenance goes, sheet metal is much easier to replace than rollers. If a hole is worn in the sheet metal, it can easily be cut out and replaced. Rollers, on the other hand, would have to be ordered; more than likely, and down time would be longer.

Schedule

See Appendix A for the Gantt chart, which is the schedule for designing and building the mock up.

Appendix A



ID	Task Name	Duration	Start	Finish
1	**Large Square Bale Quarter Turner**	**150 days?**	**Mon 11/5/12**	**Fri 5/31/13**
2	**Design**	**150 days**	**Mon 11/5/12**	**Fri 5/31/13**
20	**Prototype**	**130 days?**	**Mon 11/5/12**	**Fri 5/3/13**
21	Prototype	0 days?	Wed 1/9/13	Wed 1/9/13
22	Prototype	0 days?	Fri 5/3/13	Fri 5/3/13
23	Design	4 days?	Wed 1/9/13	Mon 1/14/13
24	Parts Ordered	5 days	Tue 1/15/13	Mon 1/21/13
25	Fabrication of Sheet Metal Turner	30 days	Tue 1/22/13	Mon 3/4/13
26	Attain Large Bales	39 days	Mon 11/5/12	Thu 12/27/12
27	Testing Sheet Metal Turner	5 days	Tue 3/5/13	Mon 3/11/13
28	Fabrication of Roller Turner	10 days	Tue 3/12/13	Mon 3/25/13
29	Testing of Roller Turner	5 days	Tue 3/26/13	Mon 4/1/13
30	**Project Material**	**130 days?**	**Mon 11/5/12**	**Fri 5/3/13**
31	Project Material	0 days?	Wed 1/9/13	Wed 1/9/13
32	Project Material	0 days?	Fri 5/3/13	Fri 5/3/13
33	Rough Draft	44 days	Mon 11/5/12	Thu 1/3/13
34	Second Draft	15 days	Fri 1/4/13	Thu 1/24/13
35	Preliminary Presentations in Class	69 days	Mon 11/5/12	Thu 2/7/13

Project: Spring Ghant Chart
Date: Tue 4/30/13

Task	External Milestone	Manual Summary Rollup	
Split	Inactive Task	Manual Summary	
Milestone	Inactive Milestone	Start-only	
Summary	Inactive Summary	Finish-only	
Project Summary	Manual Task	Deadline	
External Tasks	Duration-only	Progress	

Page 1

Appendix B

US00
5560
191A

United States Patent [lg]

Finney et al.

[11] **Patent Number: 5,560,191**

[45] **Date of Patent: Oct. 1, 1996**

[54] **JUMBO BALE ROTATING TABLE FOR A HAY BALER**

[76] Inventors: **Denzel R. Finney; Kelly D. Finney,** both of P.O. Box 131, Fort Sumner, N.M. 8811g

[21] Appl. No.: **465,018**

[22] Filed: **Jun. 5, 1995**

[51] **Int. Cl.**[6] ..... **AOID 75/04**

[52] U.S. **Cl.** ..... **56/474;** 414/744.7; 414/77g; 100/45; 100f17g; 1001188 R

[58] **Field of Search** ..... 56/474, 343, 44g, 56/432, 433, 451, 475, 476, 480; 414J77g, 754, 744.4, 744.6, 744.7; 100117g, 188 R, 45

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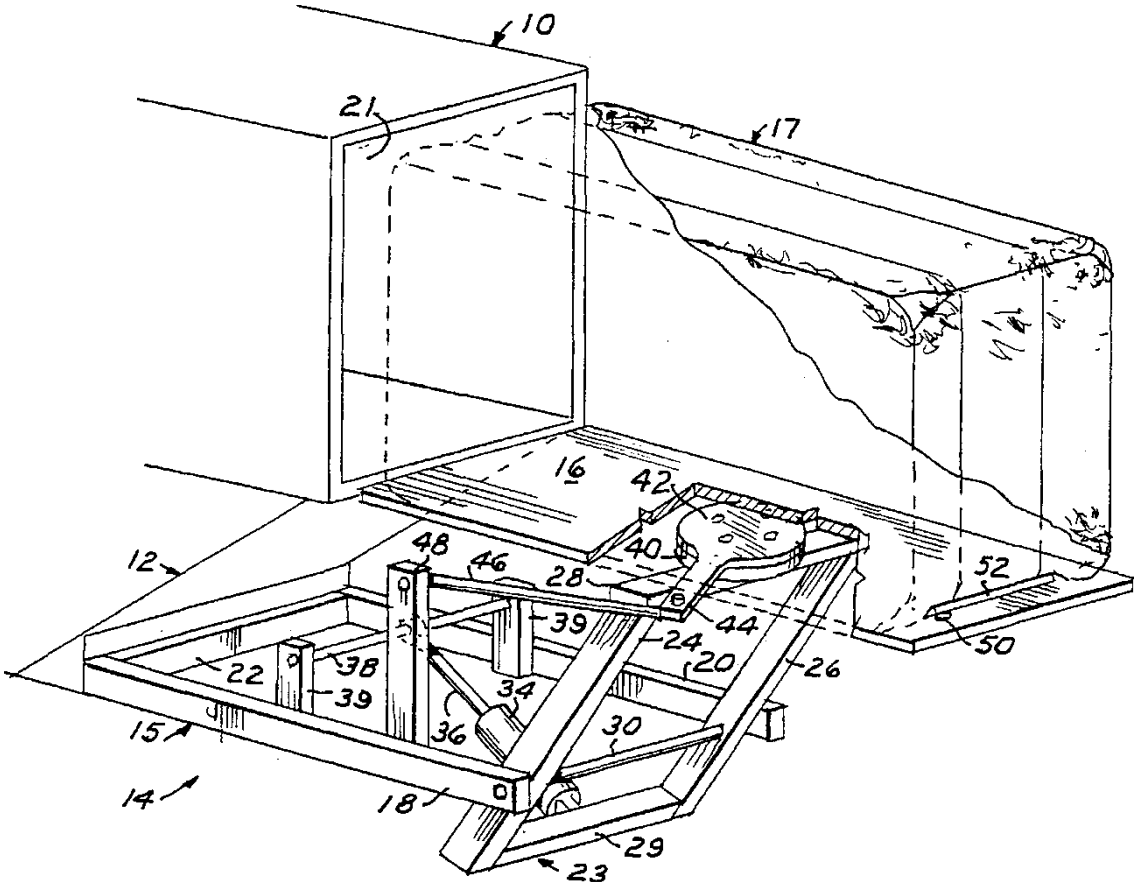
5,024,152	6/1991	Girard	100/188 R

Primary Examiner-Terry Lee Melius
Assistant Examiner-Heather Chun Schackelford
Attorney, Agent, or Firm-Robert K. Rhea

[57] **ABSTRACT**

A hay bale turntable for angularly rotating a rectangular jumbo size hay bale goo about its longitudnal axis while lowering the bale as it is received from a baler chamber to the surface of the earth is formed by a rigid bale support frame connected with the rearward end of a hay baler frame below the exit end of the hay baler bale chamber. A bale lowering arm frame is pivotally connected with the support frame for vertical pivoting movement toward and away from the surface of the earth. The arm frame supports a bale receiving platform having a bearing centrally interposed between the platform and the arm frame for angular rotation of the platform as the arm frame lowers it toward the surface of the earth by a fluid pressure cylinder connected with the support frame and arm frame. The cylinder is actuated for pivoting the arm frame by a fluid pressure pilot valve on the platform triggered by an overlying bale. Simultaneous with lowering of the bale toward the surface of the earth a tether rod connecting the platform with the support frame angularly rotates the bale goo about its longitudinal axis.

7 Claims, 2 Drawing Sheets



Appendix C

US006033172A

United States Patent [19]

Simon

[11] Patent Number: 6,033,172

[45] Date of Patent: Mar. 7, 2000

[54] **BALE TURNING APPARATUS**

[75] Inventor: **Richard L. Simon**, Wichita, Kans.

[73] Assignee: **Maize Corporation**, Maize, Kans.

[21] Appl. No.: **09/253,421**

[22] Filed: **Feb. 19, 1999**

[51] **Int. Cl.**[7] **A01D 90/00**

[52] **U.S. Cl.** **414/24.5**; 414/482; 414/483; 414/911

[58] **Field of Search** 414/24.5, 789.7, 414/111, 911, 477, 478, 482, 483; 298/9

[56] **References Cited**

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WO92/00912	1/1992	WIPO	414/477

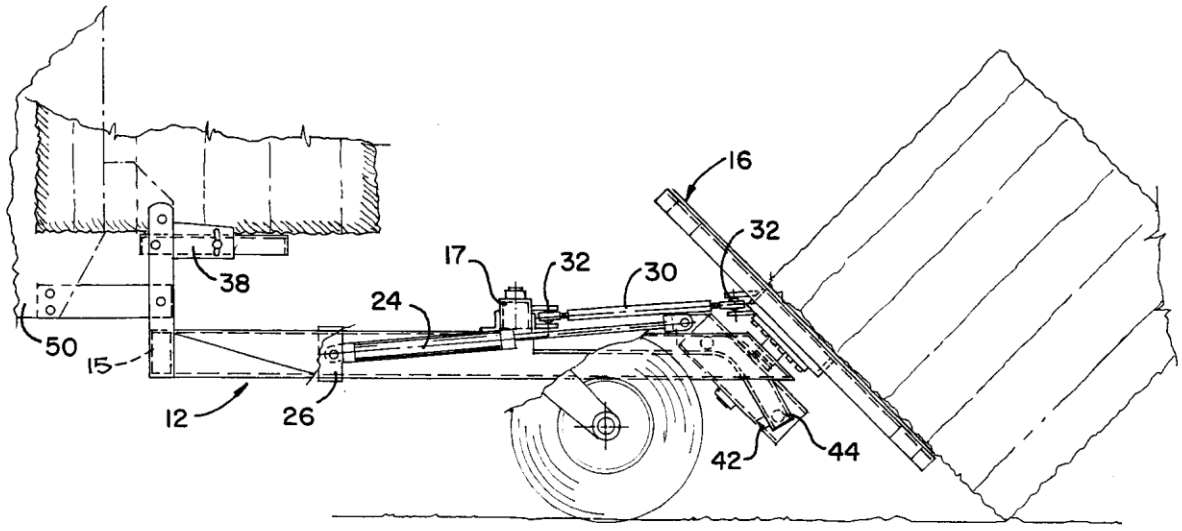
Primary Examiner—Douglas Hess

Attorney, Agent, or Firm—Edward L. Brown, Jr.

[57] **ABSTRACT**

The present invention provides a turning apparatus for receiving large bales from a baler, the apparatus includes a table for receiving the large bales which turns the bale ninety degrees from its original position as it exits from a baler and then tilts the table downward thus rolling the bale off the table. The table angle and its turning speed are adjustable for varying the position in which it is deposited off of the table.

5 Claims, 3 Drawing Sheets



Appendix D

List of Tables

Appendix E

List of Figures

Appendix F

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AGRICULTURAL DESIGN Solutions

John Boevers
Molly Johnson
Lee Morris
Wes Wegener

Mission Statement

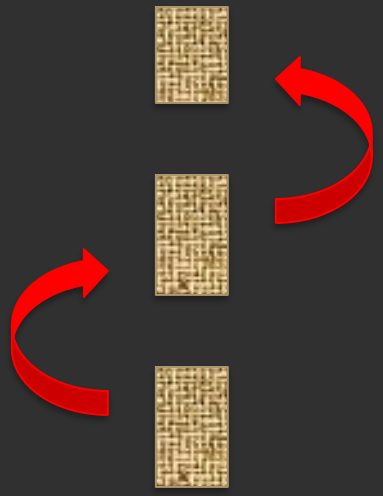
Our Mission is to provide innovative and economical solutions to the hay and forage industry that will maximize efficiency

Problem Statement

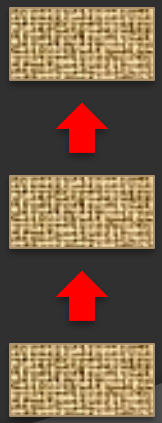
Our team was faced with the task of designing an attachment that would rotate large square bales ninety degrees along the long axis of the bales.

Why?

Without Quarter Turner



With Quarter Turner



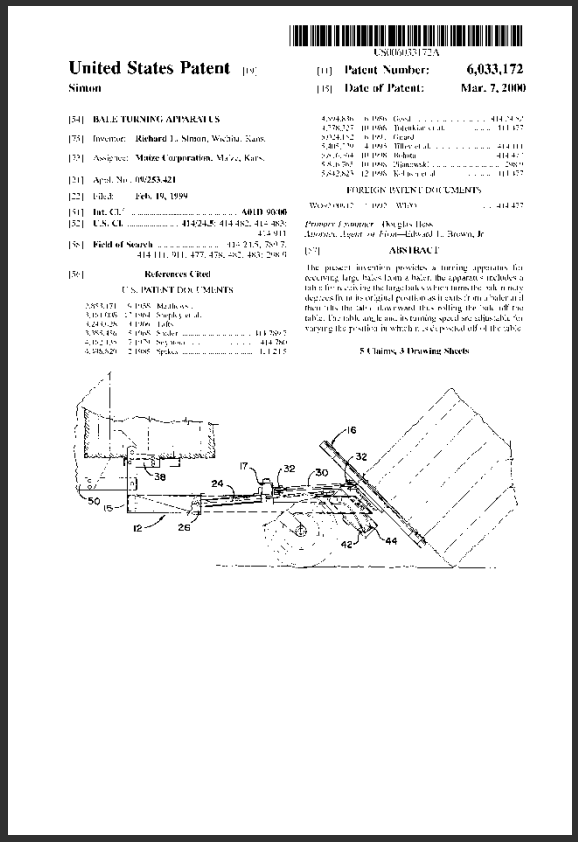
Also Considered

- Minimizing dragging the bales when released from attachment
  - Reducing soil accumulation on the bale

Work Breakdown Structure

- Documentation
  - Literature Research
- Design
- Fabrication
  - Mockup
- Testing
  - Static Friction and Load

Patents



US006033172A

United States Patent [19]
Simon

[11] **Patent Number: 6,033,172**
[15] **Date of Patent: Mar. 7, 2000**

[54] **BALE TURNING APPARATUS**

[75] Inventor: **Richard L. Simon**, Wichita, Kans.

[73] Assignee: **Maize Corporation**, Maize, Kans.

[21] Appl. No.: **09/253,421**

[22] Filed: **Feb. 19, 1999**

[51] **Int. Cl.**[7] **A01D 90/08**

[52] **U.S. Cl.** **414/24.5**; 414/482; 414/483; 414/911

[58] **Field of Search** ..... 414/215, 789.7, 414/111, 911, 477, 478, 482, 483; 298/1 R

[56] **References Cited**

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4,594,836	6/1986	Good	414/24.5
4,778,325	10/1988	Talentino et al.	414/477
5,124,152	6/1992	Girard	
5,405,230	4/1995	Bliss et al.	414/111
5,676,504	10/1997	Roberts	414/477
5,816,765	10/1998	Zlamenski	298/1 R
5,842,823	12/1998	Kelsey et al.	414/477

FOREIGN PATENT DOCUMENTS

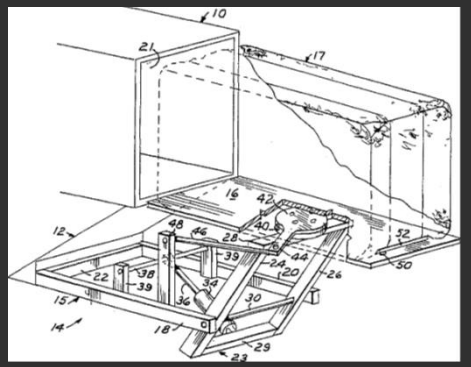
WO 93/00512 1/1993 WIPO 414/477

Primary Examiner—Douglas Hess
Attorney, Agent, or Firm—Edward L. Brown, Jr

[57] **ABSTRACT**

The present invention provides a turning apparatus for receiving large bales from a baler, the apparatus includes a table for receiving the large bale, wherein turns the bale at least 90 degrees from its original position as it exits from a baler and then tilts the bale downward thus rolling the bale off the table. The table angle and turning speed are adjustable for varying the position in which the bale is placed off of the table.

5 Claims, 3 Drawing Sheets



Bale Turning Apparatus (6033172)

Jumbo Bale Rotating Table for a Hay Baler (5560191)

“Large Square Bale Quarter Turner” – YouTube Video

Competitors

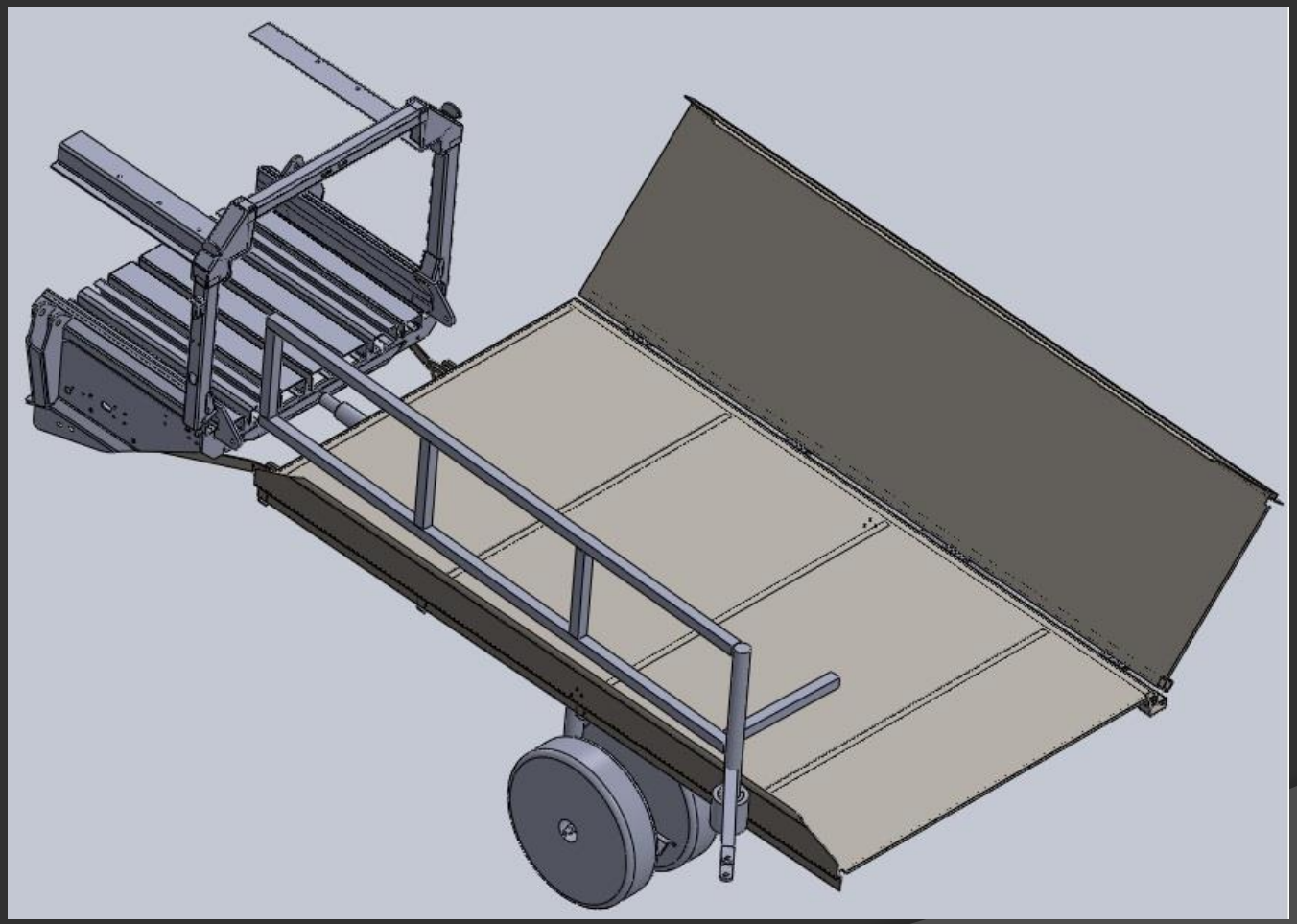

Vermeer
605
SUPER
09/13/2012

Engineering Parameters

- Bale size 4x4x9 feet
- Max bale weight 3,000 lbs
- Angle of bale chute is 6 degrees to the horizontal
- Distance from chute to ground 41 inches
- Baler can produce 70.5 bales per hour

Design

Design Concept

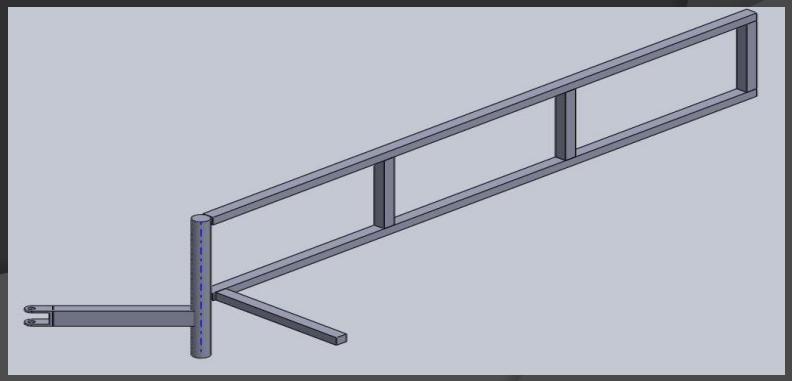


Frame

- Dimensions 10 x 11 feet
- Slide
  - Limit switch
    - Located at rear end
- Materials
  - 6” C-Channel
  - Sheet metal 3/16 inch thick

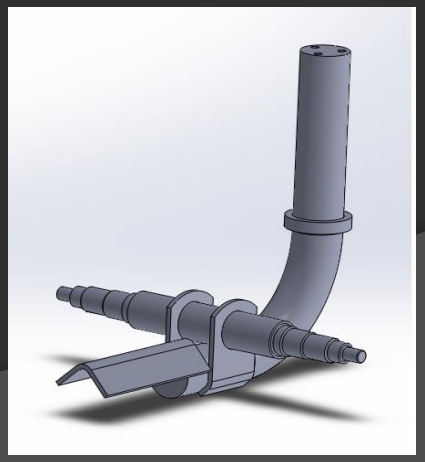
Lever Arm

- Considered hydraulic motor
- Hydraulic cylinder chosen instead
  - Cylinder 1.5 feet away from lever arm and 5 feet from lever arm pivot
- Limit switches (2)
  - Pilot controlled check valves regulate flow
  - Allows time for bale to slide off before resetting



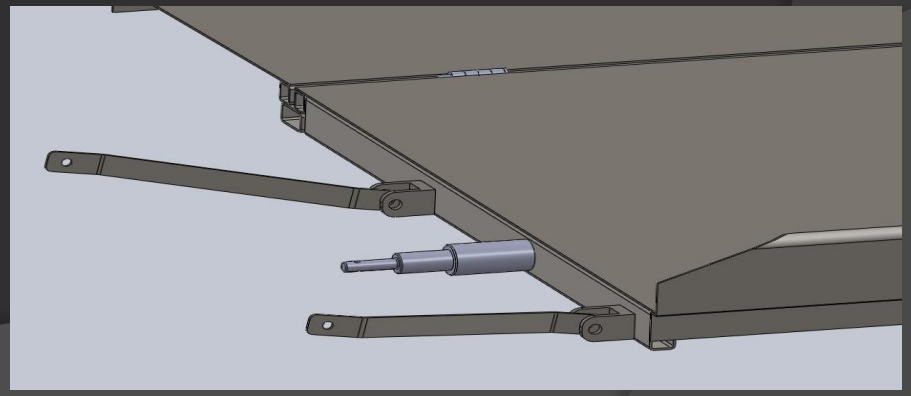
Axle

- Considered walking beam axle to compensate for twisting on uneven terrain
  - Made attachment too tall
  - Hitch flexibility allowed for simpler design
- Caster wheels



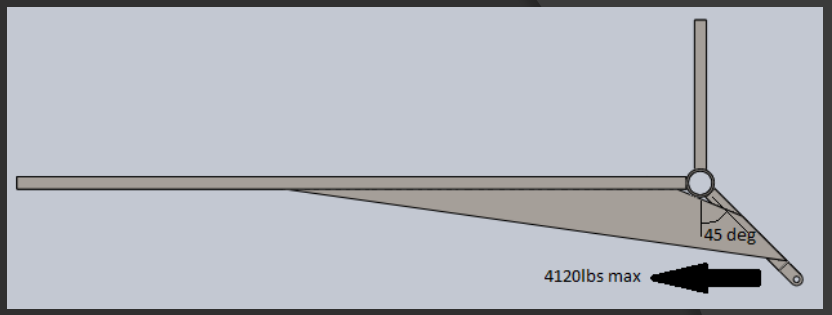
Hitch

- Hitch will be connected at 3 positions
- 2 extension tabs
- Hook up
- Focus on flexibility for uneven terrain
- Easy hookup to baler



HYDRAULICS

Hydraulics



- Hydraulic cylinder pulls on arm at a 45° angle
- Max column load of cylinder used – 4120 lbs

$$4120lbs * \sin(45°) = 2913lbs$$

- Max force cylinder exerts on bale 2913lbs

Hydraulics

- 2 inch bore, 44inch retract, 36 inch stroke, column load 4120 lbs
  - $GPM = \frac{\pi * D_p^2}{4} * S * \frac{(\frac{60}{231})}{T_e}$

T_e = Time for extension

S = Stroke

Hydraulics

- Horse Power needed to operate hydraulics for quarter turner

- $hp = \frac{GPM * PSI}{1714}$

2.5in cylinder

Time (s)	GPM(extension)	HP	GPM(retraction)
20	2.3	4.02	1.6
15	3.1	5.43	2.1
10	4.6	8.05	3.2
5	9.2	16.1	6.4
4	11.5	20.1	8
3	15.3	26.8	10.7
2.5	18.4	32.2	12.8

2in cylinder

Time (s)	GPM (extension)	HP	GPM (retraction)
20	1.5	2.6	0.9
15	2	3.5	1.2
10	3	5.3	1.8
5	5.9	10.4	3.6
4	7.4	12.8	4.5
3	9.8	17.2	6

Testing

Without Rollers

Static Friction

- Force needed to overcome static friction of bale

$$F_f = mgsin\theta \quad F_n = mgcos\theta \quad \mu = \frac{F_f}{F_n}$$

  - Testing shows $\theta = 16°, \mu_s = 0.29$

Hydraulic Calculations

- 372 lb_f to move bale
  - $\mu_s N = 0.29 * 1284$
- Equivalent to 712 psi at the cylinder

Video!!!

Testing

With Rollers

Pseudo Static Friction

- Testing shows $\theta = 8°$
- Using the same equations as before
  - μ_s= 0.14

Hydraulic Calculations

- 180 lb_f to move bale
  - $\mu_s N = 0.14 * 1284$
- Equivalent to 345 psi at the cylinder

Video!!!

Hypothetical Scenario

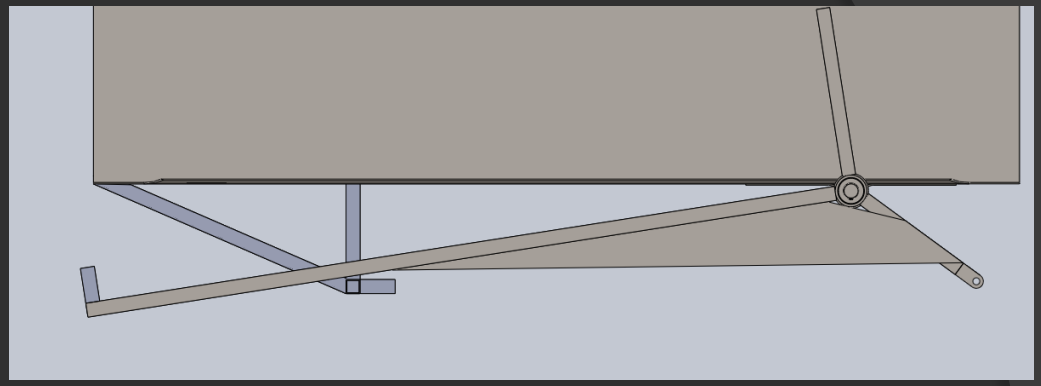
- Assuming for fresh alfalfa weighing 3,000lbs and $\mu_s = 0.7$ on sheet metal, the load required would be 2,100lbs.

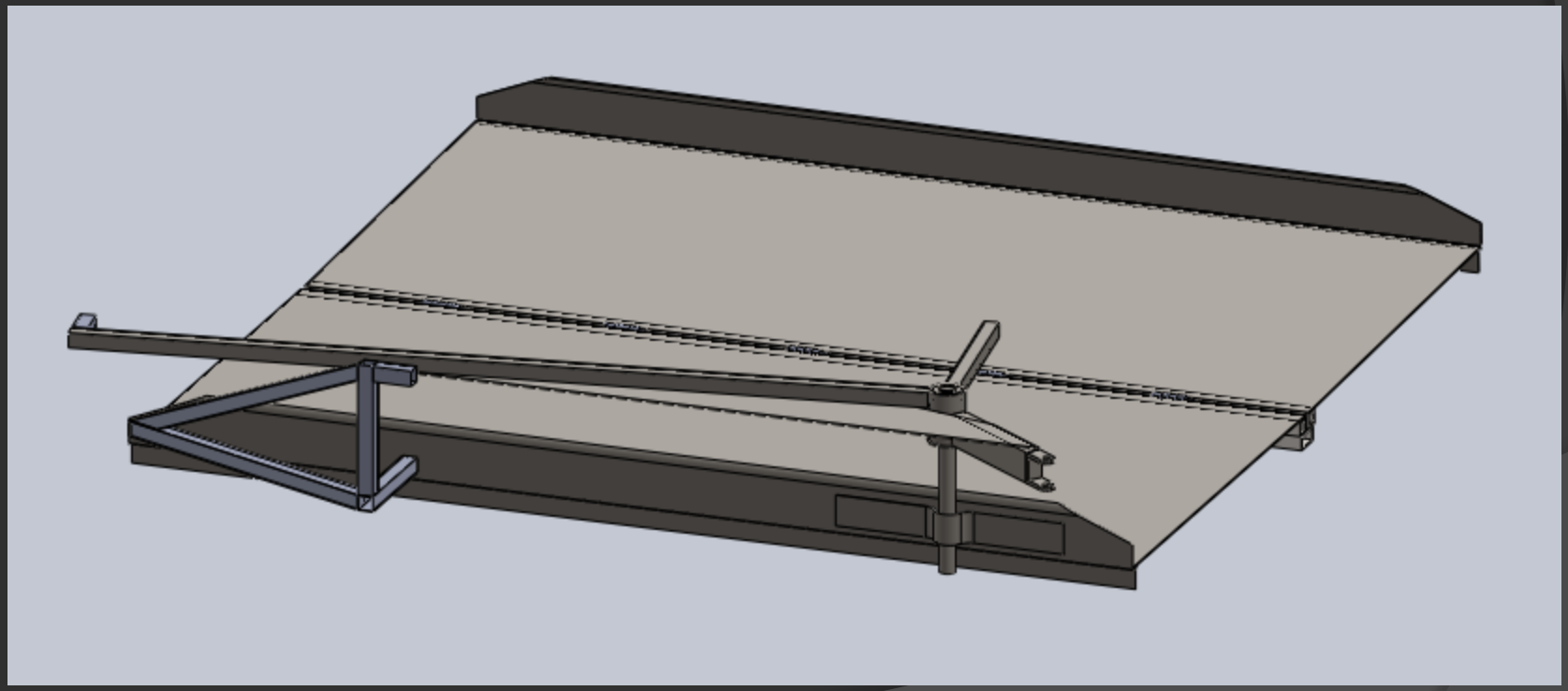
Budget for Mockup

Budget for Mockup	
Item	**Cost**
2x2x3/16 in steel tubing	
2x4x3/16 in steel tubing	
3/16 steel sheet	$699.19
2 in solid steel round	
4 in sch 40 steel pipe	
6 in C-channel	
ball bearing	donated
retainer ring	$7.00
36 in stroke hydraulic cylinder	$174.00
hydraulic hoses and fittings	donated
rollers	donated
TOTAL	$880.19

Summary

- We suggest…





Special Thanks

- AGCO
- BAE Lab
- Independent Diesel

Questions?

Design Team:

John Morris

Wes Wegener

Molly Vich

John Boevers

Mission Statement

Our mission is to provide innovative and economical solutions to the hay and forage industry that will maximize efficiency.

Table of Contents

Introduction

Problem Statement

Our team was faced with the task of designing an attachment that would rotate large square bales ninety degrees along the long axis of the bales. This has to be done before the bale is on the ground. The bale size we are focusing on is 3x4x9 feet.

Statement of Work

The purpose of this attachment is to alter the placement of the bale after is has been ejected from the baler and before it hits the ground. The final placement of the bales is to be ninety degrees from its original position orientation when leaving the baler. The design of this attachment will also focus on minimizing the dragging of the bales on the ground and therefore reducing soil accumulation on the bales. The designing of this attachment and its options started in September and should be completed by December 7th, 2012. The making of either a prototype or a scale model will begin January 14th, 2013 and run through May 10th, 2013. Our deliverables are a schedule of events and a completed design. The time schedule on our deliverables is the same as the schedule for our designing, ending on December 7th, 2012. The acceptance criteria for this attachment is if the bale is turned ninety degrees before it gets to the ground and that there is no more than four inches of sliding once on the ground.

Work Breakdown Structure

The Large Square Bale Quarter Turner is broken down into four parts: documentation, design, testing, and fabrication. Documentation deals with patent searches, market research,

competitive analysis, and any other research that needs to be done. After documentation comes design. Design is broken down into five parts: Connection Mechanism, Axle Component, Frame, Hydraulic/Power System, and Turning Mechanism. We know that however we decide to attach the quarter turner it has to able to move instead of being solid, unmovable hitch. The Axle Component is broken down into Support and Tires. Support deals with how the attachment is supported. Our options were using an axle, caster wheels, or a walking axle with caster wheels. We went with caster wheels because they allow for easier turning. Tires includes the size and number of tires. We went for two tires on each caster with two casters to support the weight. For our Turning Mechanism we had options for rollers, gravity drive, and a swing arm. We ended up combining a gravity drive and swing arm where the swing arm is what turns the bale and gravity makes it slide to the ground. The swing arm will turn the bale ninety degrees. After this happens, the bale will only be sitting on 1.5 feet of the frame where it will tip and slide down a slide that is angled towards the ground. Testing is the next step. This is when stress and fatigue analyses are performed. These analyses will be preformed in Solid Works for now. Once we have a working model or prototype there can be more testing performed to identify any problems that my arise during operation. Lastly is fabrication. This deals with taking the design and making either a working model or prototype once we have determined which one will be built.

Task List

From the beginning, our tasks include finalizing plans; making a schedule; determining materials to be used and costs; creating computer drawings; determining if we are making a working model, a prototype, or both; analyzing stresses and loads. We have to determine which

options we want to go with and finalize how they will work. Our schedule will be a Gantt chart that your can find in Appendix A. The materials and costs associated with them can be found in Table 1 on page 13. A list of all figures and drawings can be found in Appendix E. As far as a prototype or working model goes, for now we are running on the impression that we will just be making a working model. Just in case we do end up making a prototype, we scheduled in time for next semester to accomplish that. As for testing, we will perform stress analysis in solid works to determine if our design will hold up under the loads it will experience.

Analysis and Research

Competitive Analysis

Competition in the hay and forage industry is low, with the three largest players Deere & Company, CNH Global NV and AGCO Corporation; all three accounting for more than half of all industry revenue. These large, diversified companies are "price makers" within the industry; therefore, price-based competition between them is low. Instead, the industry's leading firms primarily compete on product quality, performance and innovation; efficient production and distribution arrangements; customer service; and the establishment of brand names. There are no licensing requirements, government regulations or resource constraints that are significant enough to prevent firms from entering the industry (IBIS*World*, 2012).

"The acquisition of manufacturing facilities fitted with the equipment required to manufacture agricultural equipment requires a large capital investment. The magnitude of this financial commitment deters some firms from entering the industry. There is also a medium concentration of firms within this industry, giving them the ability to exercise a high degree of

market power." According to the industry report, "The cost of entering and competing with incumbent firms that have strong relationships in downstream markets and long histories may also deter some firms from entering" (IBIS*World*, 2012).

Market Research

Major players in the marketplace include AGCO Corp., Claas KGaA mbH, CNH Global NV, Deere & Company (John Deere), Escorts Group, Iseki & Co. Ltd., Kubota Corp., Kuhn Group, Kverneland ASA, Mahindra Group, Same Deutz-Fahr Group, and Tractors and Farm Equipment Ltd. (Western Farm Press, 2011). With over 1,000 enterprises operating in this industry, the top-two companies, Deere & Company and CNH Global NV generate about 55.8% of all revenue for agricultural machinery (IBIS*World*, 2012). How much of this revenue is from the sales of haying equipment and attachments is unknown. A high level of research and development, large economies of scale, extensive dealer networks and longstanding reputations make it difficult for new players to compete with the major operators.

"Deere & Company is the world's leading manufacturer of agricultural and forestry equipment with a market share of 44.2%. While severe summer drought conditions in the Midwest took a heavy toll on the nation's crops in 2012, record commodity prices and the widespread use of crop insurance in the United States are expected to protect and even boost farmers' incomes, contributing to an increase in demand for agricultural equipment. On the back of this strong demand, revenue from Deere's industry-relevant operations is expected to increase 2.6%."

(IBIS*World*, 2012)

Also included in the industry report:

"CNH Global NV is the world's second-largest manufacturer of agricultural equipment with a market share of 11.6%. CNH sells these products through 12,000 dealers and distributors in 160

countries. The company also services a worldwide net managed portfolio of more than $18.0 billion, helping with dealer and customer equipment financing throughout North America, Latin America and Australia. CNH has a significant global presence: about 38.0% of the company's revenue comes from North America, 33.0% from Western Europe, 12.0% from Latin America and 18.0% from the rest of the world. North America equipment operations encompass operations in Canada, the United States and Mexico, with an estimated 64.0% of North America agricultural equipment revenue coming solely from operations within the United States."

(IBIS*World*, 2012)

Current hay and forage equipment market share for Deere & Company, CNH and AGCO are unknown at this time.

Patent Search

There are two patents that are relative to our project in that they are solutions to the exact same problem that we are faced with. One is the Jumbo Bale Rotating Table for a Hay Baler and the other is the Bale Turning Apparatus. Denzel R. Finney and Kelly D. Finney, of Fort Sumner, New Mexico, hold the patent for the Jumbo Bale Rotating Table for a Hay Baler. The patent number is 5560191 and was filed on June 5, 1995. The U.S. classification is 56/474; 100/45; 100/179; 100/188.00R; 414/744.7; 414/779. For the Bale Turning Apparatus, Richard L. Simon of Wichita, Kansas is the inventor, but Maize Corporation out of Maize, Kansas, holds the patent. The patent number is 6033172 and was filed on February 19, 1999. In the U.S., the classification is 414/24.5; 414/482; 414/483; 414/911. The first patent found was the Jumbo Bale Rotating Table for a Hay Baler. This patent produced an idea of using a turntable, but making it a trailer like attachment instead of one supported by the frame. Further patent searching uncovered the Bale Turning Apparatus. The original idea of a turntable was scratched

after finding this patent due to the fact that the idea was very similar to the already existing patent. From these patents, the choice was made to stick with the original trailer like attachment but instead of a turntable, using a swing arm to push the bale around ninety degrees. These patents can be seen in Appendix B and Appendix C.

Impacts

There are some possible societal impacts that could stem from using this device. The largest impact would be the increase in efficiency and time saved. Even though it does not seem like it would save much time, it begins to add up with each bale and the time savings is noticed when pulling out of the field. Not only is time saved, but also in theory, fuel consumption can be lowered. Instead of driving through a hay field having to swerve to pick up bales, a person can follow the windrows through the field taking the same path as the tractor and baler. This is a more direct path to pick up the bales and therefore shorter. This means that the productivity of the machine used to pick up the bales goes up due to the fact that it could pick up more bales in the same amount of time when compared to not using a bale quarter turner behind a baler.

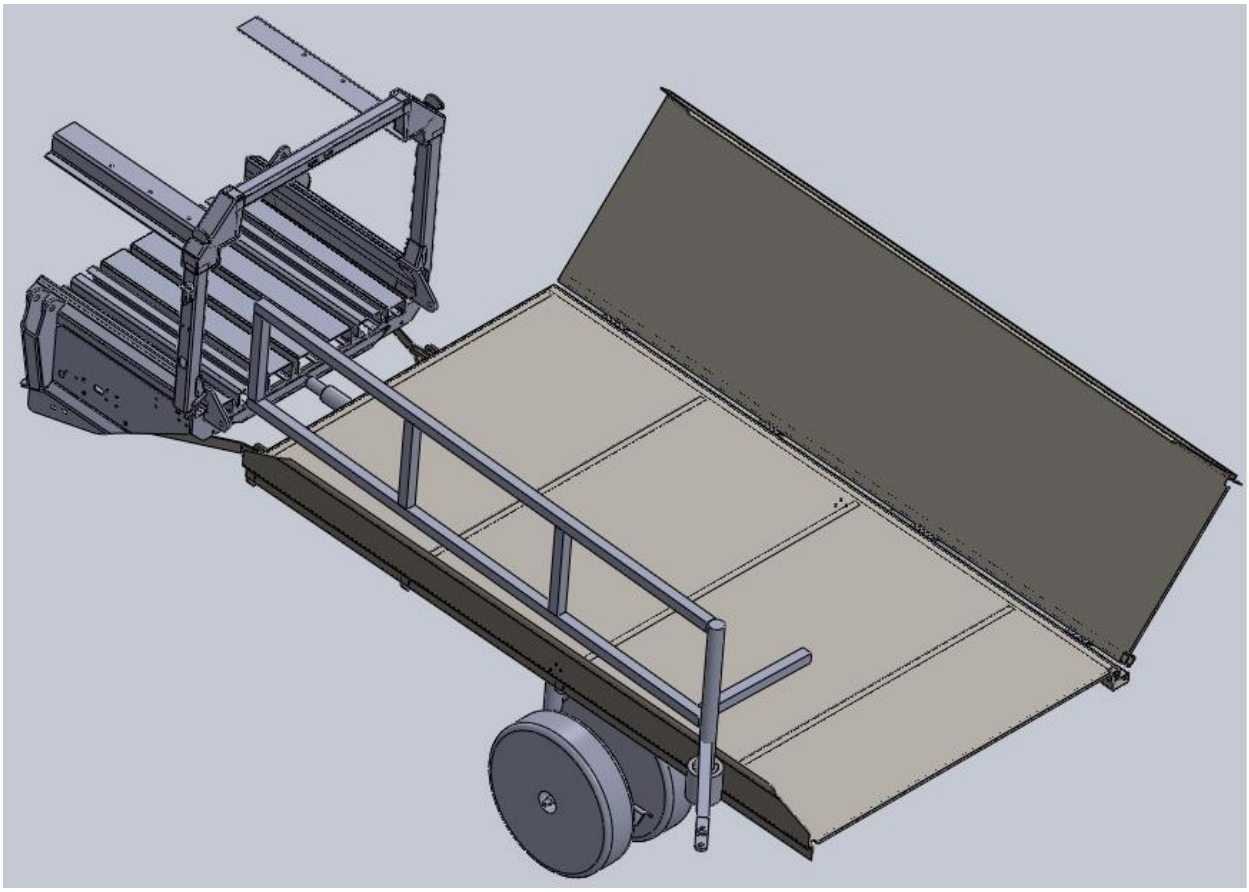
Customer Requirements

AGCO wants us to design an attachment that turns a large square bale ninety degreed on its longitudinal axis from the original orientation out of the baler. They want us to minimize the cycle time or at least justify it to make sure it can run as fast as the baler can produce bales. The retail price of this attachment is to be approximately $15,000 or lower if at all possible. AGCO wants the design of this attachment to be as simple as possible.

Engineering Specifications

The quarter turner attachment will be a pull type attachment instead of an attachment that connects to the frame and doesn't have wheels and tires. The largest bale size that the attachment can handle will be 4x4x9 feet. It will have a frame that the bale slides on to that measures 10x10.5 feet. The width of ten feet was determined by finding the diagonal length of the bale. The Pythagorean theorem for right triangles was used to find this diagonal length, using bales that are four feet wide and nine feet long, of 9.85 feet. Ten feet was chosen for the width to allow for some clearance so the bales do not get stuck while turning. Realizing that .15 feet is more than likely not enough clearance, the frame will more than likely be widened to 10.5 feet. This can only be determined though through testing which will come next semester. This frame is made out of 2x4 steel tubing that is 3/16 inch thick and 3/16 inch steel plate. These sizes and thicknesses were determined by estimations that came from looking at AGCO accumulators. Further testing will determine whether or not smaller or larger sizes will be needed based on the design factor that we choose of ten. This design factor was chosen in order to better ensure that the quarter turner would not break under negligent conditions like hitting trees or other machinery. This frame will have one side that folds up using a hydraulic cylinder. This side that folds will be three feet wide and have a cylinder with a twenty-inch stroke and overall length of forty-eight inches. The column load for this cylinder is 7930 pounds (SOURCE: Bailey). On the next page is a figure of the quarter turner with the wing partially folded up.

Figure 1: Wing partially folded



Two casters will be used to support the weight of the quarter turner and the bale. Each caster will have two tires, one on either side of each caster. Each of theses tires it rated for 1610 pounds at forty miles per hour. The size of these tires is 6.70-15SL (SOURCE: Pete's Tire Barn). There will be a swing arm along the left side of the frame. This arm will pivot two feet from the back end of the frame. The arm will made of 2x2 inch tubing that is 3/16 inch thick. It will pivot around a three-inch solid steel rod. There are two rails on the arm that are 1.5 feet apart and nine feet long. It is these rails that will actually come into contact with the bales and swing them around. These rails have three vertical supports between them that are spaced three

feet apart down the length of the two rails. A hydraulic cylinder moves the swing arm. This cylinder has a forty-four inch retracted length with a thirty-six inch stroke making its total extended length eighty inches. Also, it has a 2.5-inch bore with a 1 3/8 inch rod diameter and is capable of handling 6230 pounds as its column load (SOURCE: Bailey). This cylinder was chosen because it was calculated, using a static friction coefficient of .71 (SOURCE: Di Cristoforo & Sweatman, 2004) and a maximum bale weight of 3000 pounds, that the force to push the bale across the steel plate is 2130 pounds.

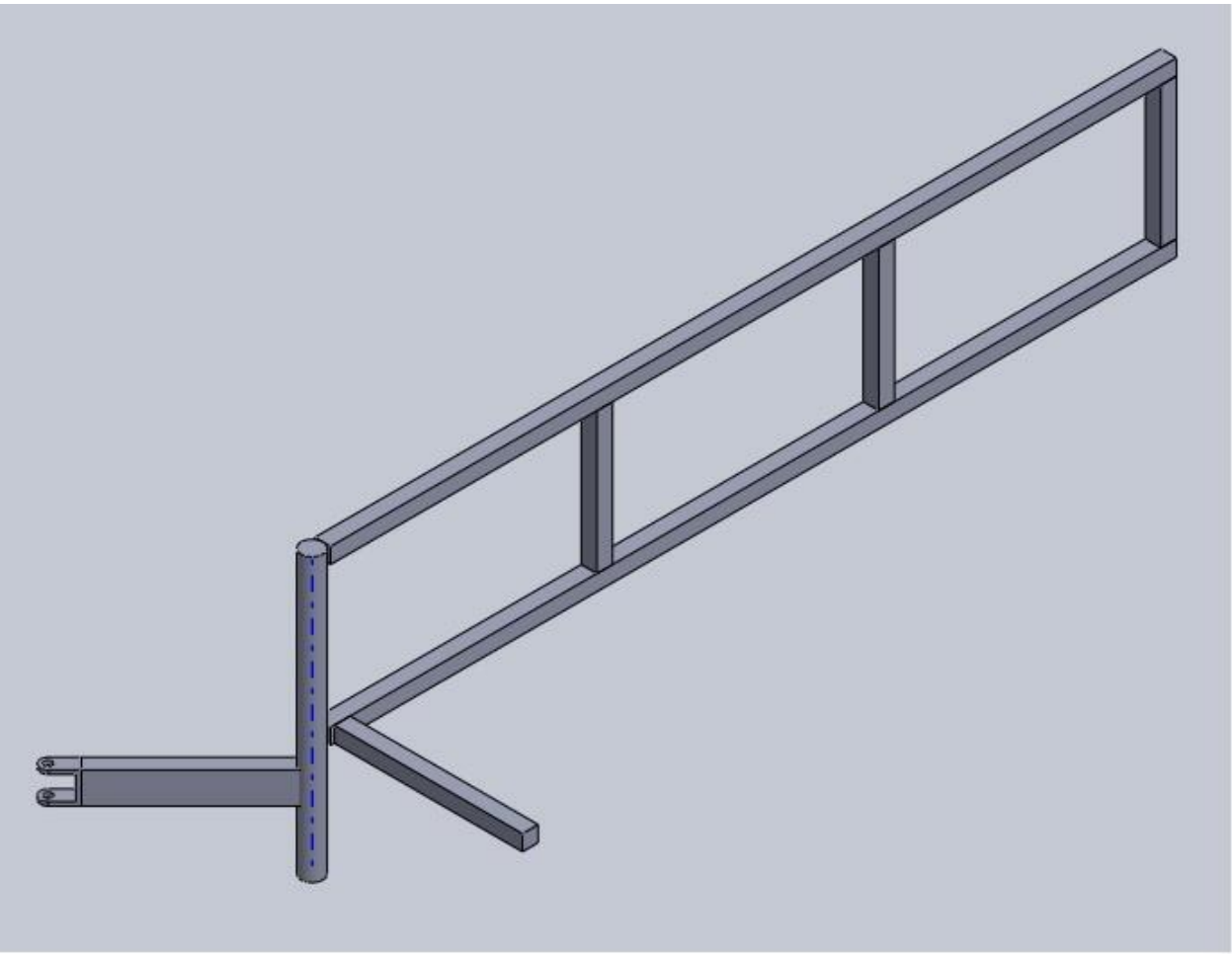
$$.71 * 3000\ lb = 2130\ lb$$

Since the cylinder is not acting on the bale directly, and instead is pulling on a beam attached to the swing arm pivot at a forty-five degree angle, the maximum force from the cylinder exerts on the bales is 4406 pounds.

$$6230\ lb * \sin 45° = 4406\ lb$$

6230 pounds is the maximum weight that the cylinder can handle. This cylinder will be attached to the frame by the same 2x4 tubing that helps support the steel plate. The cylinder will be offset from the frame by 1.41 feet. This offset was determined by taking the square root of two since the beam that the opposite end of the cylinder is attached to is two feet long and positioned at forty-five degrees. The swing arm can be seen on the next page in Figure 2.

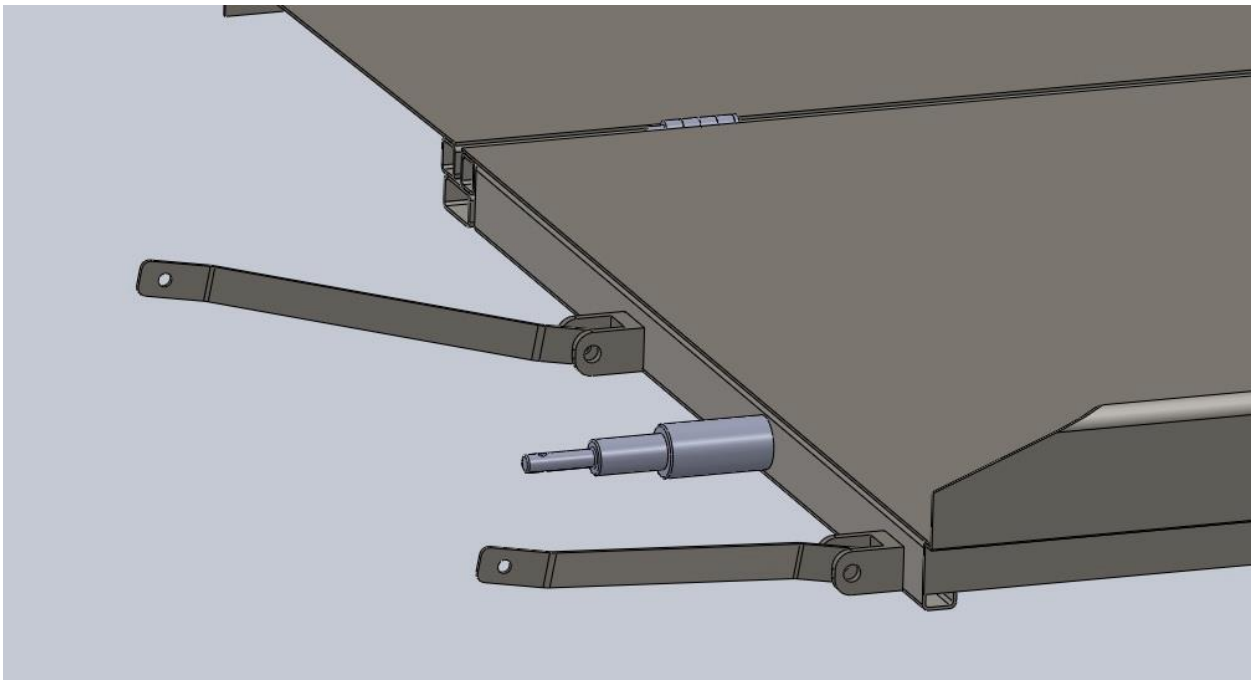
Figure 2: Swing arm



The quarter turner and bale weight will be supported by two caster wheels. The tires are rated for 1610 pounds apiece (SOURCE: Pete's Tire Barn) and the estimated maximum weight of the quarter turner with a three thousand pound bale on it is 5000 pounds. This was estimated by looking up the weights of the materials and multiplying that by the amount of each material that was used. Since some of the weight will be on the hitch, the tires do not have to endure the full five thousand pound load. Therefore, 4 tires rated at 1610 pounds will be able to carry the weight. On the back of the frame that the bale sets on, there will be an extension that the bale will slide down before it hits the ground.

This extension will allow the bales to be one foot off the ground before they drop off the quarter turner. This height was determined by looking at the pick up attachment on the baler. It was estimated that the attachment could not rise any higher than one foot. From this estimate, the minimum height of the end of the slide was determined. The hitch that attaches the quarter turner to the baler will have two ways in which it can move so that the quarter turner can follow behind the baler on a wider range of terrains without breaking the hitch. It will be able to pivot almost like a hinge to allow the quarter turner to go over hills. There are also two side supports that let the quarter turner twist and still remain attached to the baler. This allows the quarter turner to lean left and right, as the baler is taken sideways across slopes in the landscape. The hitch can be seen below in Figure 3.

Figure 3: Hitch

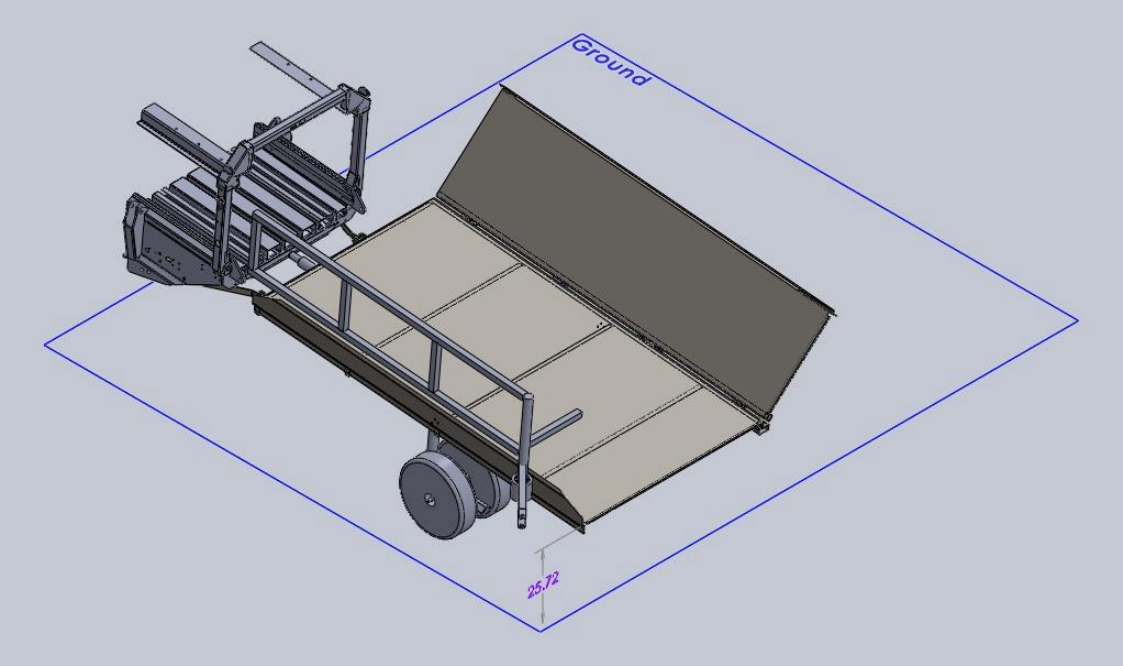


Design Concepts

For the hitch, it was known that it had to be made flexible so it wouldn't break when the baler and quarter turner aren't perfectly in line with each other. It will be able to pivot for going up and down hills as well as tilt from side to side. If the hitch of the quarter turner were to be made to where it could not move or be flexible then the quarter turner would come of the ground when going over the top of a hill and would get twisted and break when going over uneven terrain. To prevent this, the hitch would have to be much stronger and it would have increased our costs dramatically. This is why the choice was made to go with a flexible hitch. The main solution for actually turning the bale will use a hydraulic cylinder to pull an arm around that will turn the bale. A hydraulic motor was looked into to rotate the shaft that the arm is mounted to but it was determined that the cost of using a hydraulic motor is greater than using a hydraulic cylinder. This is what encouraged the use of a cylinder. The swing arm will stop and return to its original position once the bale reaches ninety degrees from its original orientation. This will be done by using limit switches that will trip pilots that control valves that restrict the flow of hydraulic fluid. Two limit switches will be used. One will be located on the back of the swing arm 1.5 feet from the pivot along the beam that stops the bales from sliding off before they are turned. The other limit switch will be located on the end of the slide. This is so the bales have time to slide out of the way of the arm before it returns to its original position. All of our options will use caster wheels to help support some of the load of the bale and quarter turner. Using a walking beam axle was considered to compensate for the twisting of the quarter turner as it goes over uneven terrain. This was thrown out after we designed our hitch and determined that the walking beam wasn't needed. Also, the walking beam would have made our quarter turner taller

and if gravity is to be used, then the frame has to be sloped for the bales to slide back. Using casters allow for a shorter design. The main materials we will use are 2x2 and 2x4 steel tubing, both 3/16 of an inch thick, and steel sheet metal that is also 3/16 of an inch thick. These sizes and thicknesses are estimations from looking at large square bale accumulators. Since our design is similar to an accumulator it is appropriate that we use materials that an accumulator would have in its construction. Since we are only handling one large square bale at a time instead of three like the accumulator, it was assumed that the quarter turner would have the same or higher safety factor since the same materials are being used in both the accumulator and quarter turner. Further testing and calculations will determine what the actual safety factor of the quarter turner will be. The quarter turner is split into two sections. The left side is seven feet wide and has the swing arm attached to it, whereas the right side is three feet wide and will be able to fold up. This is to allow for easier transportation while the quarter turner is being pulled behind the baler. The right side will fold up using a hydraulic cylinder. The cylinder will have a twenty-inch stroke and an overall length of forty-eight inches. The calculations as for why this cylinder was chosen can be found in the Engineering Specifications section. On the next page, in Figure 4, is the proposed quarter turner.

Figure 4: Proposed quarter turner



Schedule

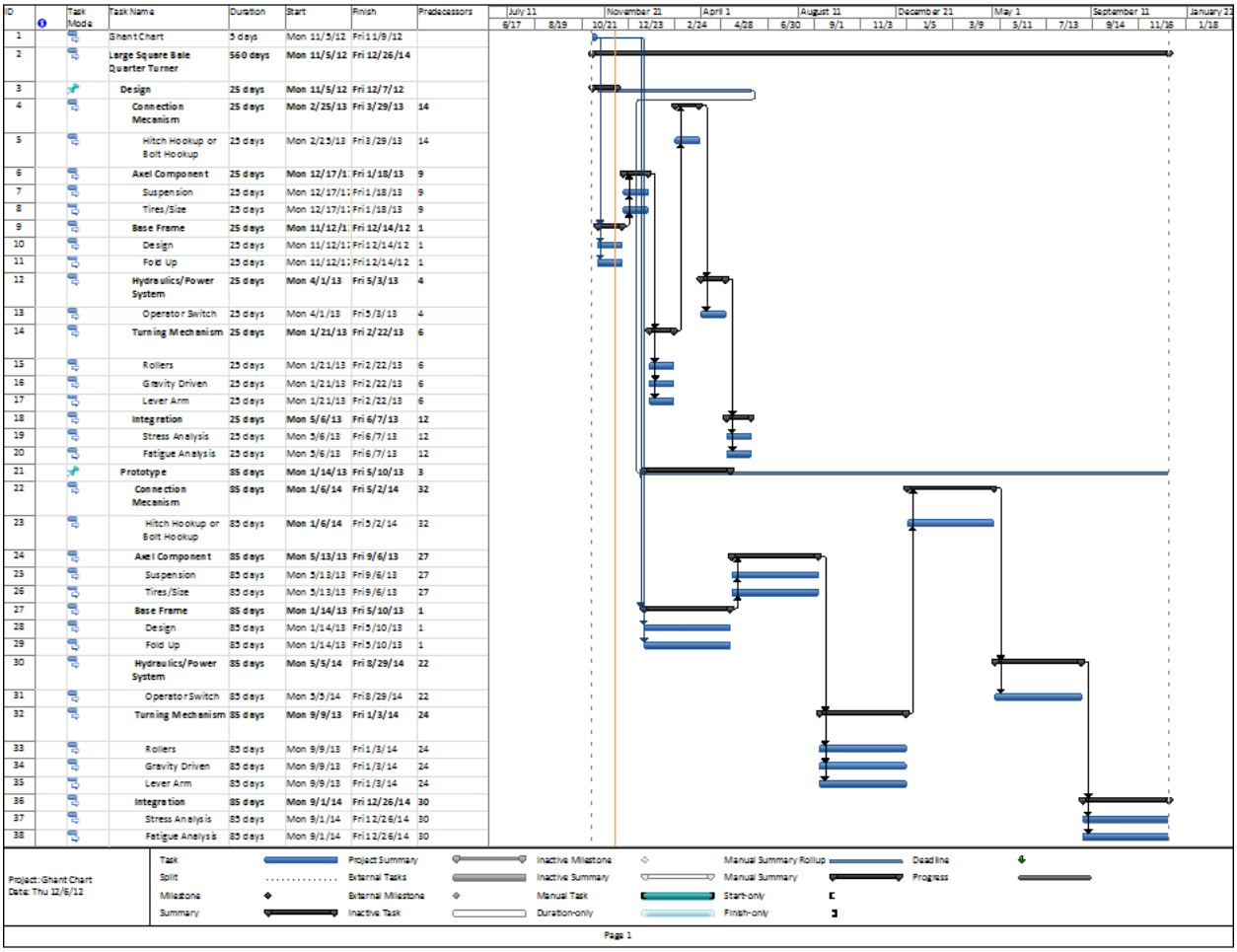
See Appendix A for our Ghant chart, which is our proposed schedule for designing and prototyping/modeling.

Budget

Table 1: Prototype budget

Proposed Budget for a Prototype				
Item	**Priced per...**	**Quantity**	**Cost/Unit**	**Total**
2x4x3/16 in.hot rolled steel tubing	foot	38.5	$6.58	$253.33
2x2x3/16 in. hot rolled steel tubing	foot	47.5	$4.16	$197.60
3/16 in. mild steel A36 hot rolled plate	square foot	126	$10.20	$1,285.20
44 in. retract hydraulic cylinder		1	$220.00	$220.00
28 inch retract hydraulic cylinder		1	$169.00	$169.00
tires		4	$63.43	$253.72
miscellaneous parts (hose, pins, pilots, etc)		X	$1,000.00	$1,000.00
labor	hour	24	$21.00	$504.00
			Total	$3,882.85

Appendix A



ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Ghant Chart	5 days	Mon 11/5/12	Fri 11/9/12	
2		**Large Square Bale Quarter Turner**	**560 days**	**Mon 11/5/12**	**Fri 12/26/14**	
3		**Design**	**25 days**	**Mon 11/5/12**	**Fri 12/7/12**	
4		**Connection Mecanism**	**25 days**	**Mon 2/25/13**	**Fri 3/29/13**	14
5		Hitch Hookup or Bolt Hookup	25 days	Mon 2/25/13	Fri 3/29/13	14
6		**Axel Component**	**25 days**	**Mon 12/17/1**	**Fri 1/18/13**	9
7		Suspension	25 days	Mon 12/17/1	Fri 1/18/13	9
8		Tires/Size	25 days	Mon 12/17/1	Fri 1/18/13	9
9		**Base Frame**	**25 days**	**Mon 11/12/1**	**Fri 12/14/12**	1
10		Design	25 days	Mon 11/12/1	Fri 12/14/12	1
11		Fold Up	25 days	Mon 11/12/1	Fri 12/14/12	1
12		**Hydraulics/Power System**	**25 days**	**Mon 4/1/13**	**Fri 5/3/13**	4
13		Operator Switch	25 days	Mon 4/1/13	Fri 5/3/13	4
14		**Turning Mechanism**	**25 days**	**Mon 1/21/13**	**Fri 2/22/13**	6
15		Rollers	25 days	Mon 1/21/13	Fri 2/22/13	6
16		Gravity Driven	25 days	Mon 1/21/13	Fri 2/22/13	6
17		Lever Arm	25 days	Mon 1/21/13	Fri 2/22/13	6
18		**Integration**	**25 days**	**Mon 5/6/13**	**Fri 6/7/13**	12
19		Stress Analysis	25 days	Mon 5/6/13	Fri 6/7/13	12
20		Fatigue Analysis	25 days	Mon 5/6/13	Fri 6/7/13	12
21		**Prototype**	**85 days**	**Mon 1/14/13**	**Fri 5/10/13**	3
22		**Connection Mecanism**	**85 days**	**Mon 1/6/14**	**Fri 5/2/14**	32
23		Hitch Hookup or Bolt Hookup	85 days	Mon 1/6/14	Fri 5/2/14	32
24		**Axel Component**	**85 days**	**Mon 5/13/13**	**Fri 9/6/13**	27
25		Suspension	85 days	Mon 5/13/13	Fri 9/6/13	27
26		Tires/Size	85 days	Mon 5/13/13	Fri 9/6/13	27
27		**Base Frame**	**85 days**	**Mon 1/14/13**	**Fri 5/10/13**	1
28		Design	85 days	Mon 1/14/13	Fri 5/10/13	1
29		Fold Up	85 days	Mon 1/14/13	Fri 5/10/13	1
30		**Hydraulics/Power System**	**85 days**	**Mon 5/5/14**	**Fri 8/29/14**	22
31		Operator Switch	85 days	Mon 5/5/14	Fri 8/29/14	22
32		**Turning Mechanism**	**85 days**	**Mon 9/9/13**	**Fri 1/3/14**	24
33		Rollers	85 days	Mon 9/9/13	Fri 1/3/14	24
34		Gravity Driven	85 days	Mon 9/9/13	Fri 1/3/14	24
35		Lever Arm	85 days	Mon 9/9/13	Fri 1/3/14	24
36		**Integration**	**85 days**	**Mon 9/1/14**	**Fri 12/26/14**	30
37		Stress Analysis	85 days	Mon 9/1/14	Fri 12/26/14	30
38		Fatigue Analysis	85 days	Mon 9/1/14	Fri 12/26/14	30

Appendix B

US00
5560
191A

United States Patent [lg]

Finney et al.

[11] **Patent Number: 5,560,191**

[45] **Date of Patent: Oct. 1, 1996**

[54] **JUMBO BALE ROTATING TABLE FOR A HAY BALER**

[76] Inventors: **Denzel R. Finney; Kelly D. Finney,** both of P.O. Box 131, Fort Sumner, N.M. 8811g

[21] Appl. No.: **465,018**

[22] Filed: **Jun. 5, 1995**

[51] **Int. Cl.**[6] ..... **AOID 75/04**

[52] U.S. **Cl.** ..... **56/474;** 414/744.7; 414/77g; 100/45; 100f17g; 1001188 R

[58] **Field of Search** ..... 56/474, 343, 44g, 56/432, 433, 451, 475, 476, 480; 414J77g, 754, 744.4, 744.6, 744.7; 100117g, 188 R, 45

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3,820,453	6/1974	Tipton	1001188 R
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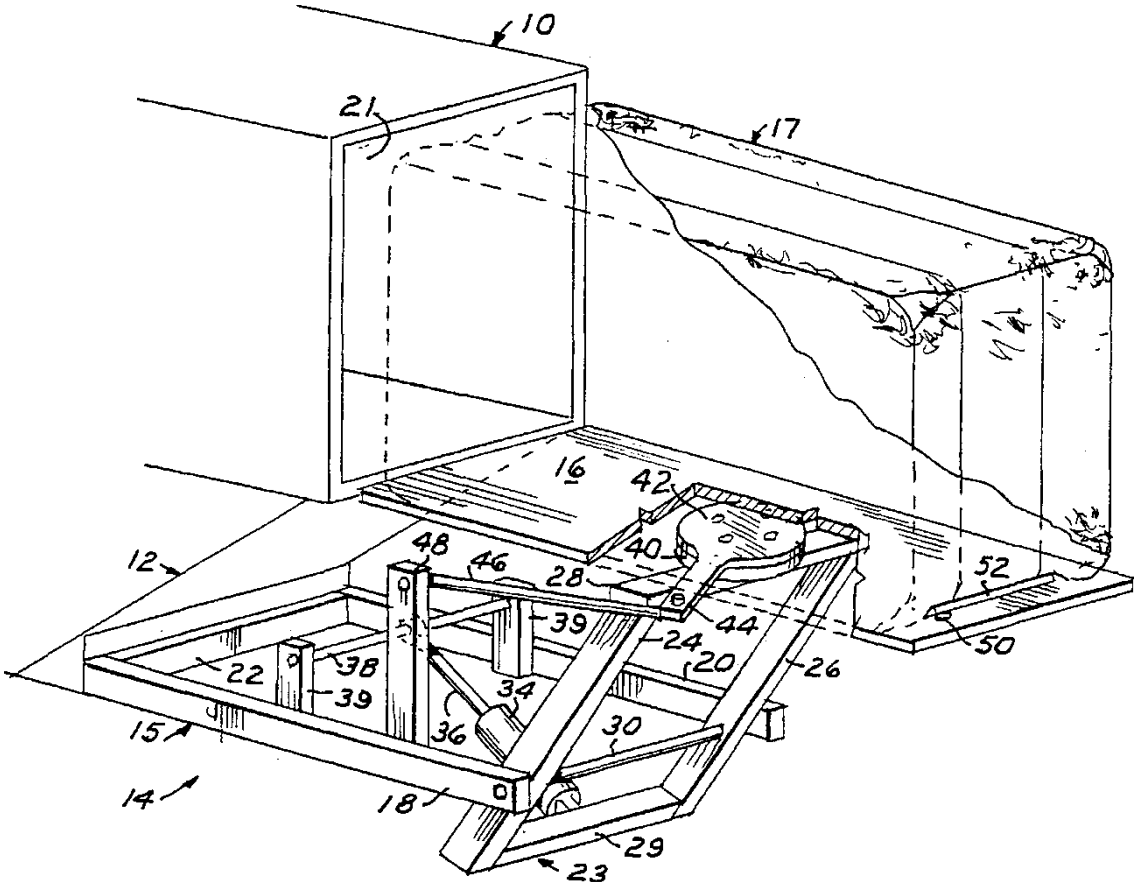
5,024,152	6/1991	Girard	100/188 R

Primary Examiner-Terry Lee Melius
Assistant Examiner-Heather Chun Schackelford
Attorney, Agent, or Firm-Robert K. Rhea

[57] **ABSTRACT**

A hay bale turntable for angularly rotating a rectangular jumbo size hay bale goo about its longitudnal axis while lowering the bale as it is received from a baler chamber to the surface of the earth is formed by a rigid bale support frame connected with the rearward end of a hay baler frame below the exit end of the hay baler bale chamber. A bale lowering arm frame is pivotally connected with the support frame for vertical pivoting movement toward and away from the surface of the earth. The arm frame supports a bale receiving platform having a bearing centrally interposed between the platform and the arm frame for angular rotation of the platform as the arm frame lowers it toward the surface of the earth by a fluid pressure cylinder connected with the support frame and arm frame. The cylinder is actuated for pivoting the arm frame by a fluid pressure pilot valve on the platform triggered by an overlying bale. Simultaneous with lowering of the bale toward the surface of the earth a tether rod connecting the platform with the support frame angularly rotates the bale goo about its longitudinal axis.

7 Claims, 2 Drawing Sheets



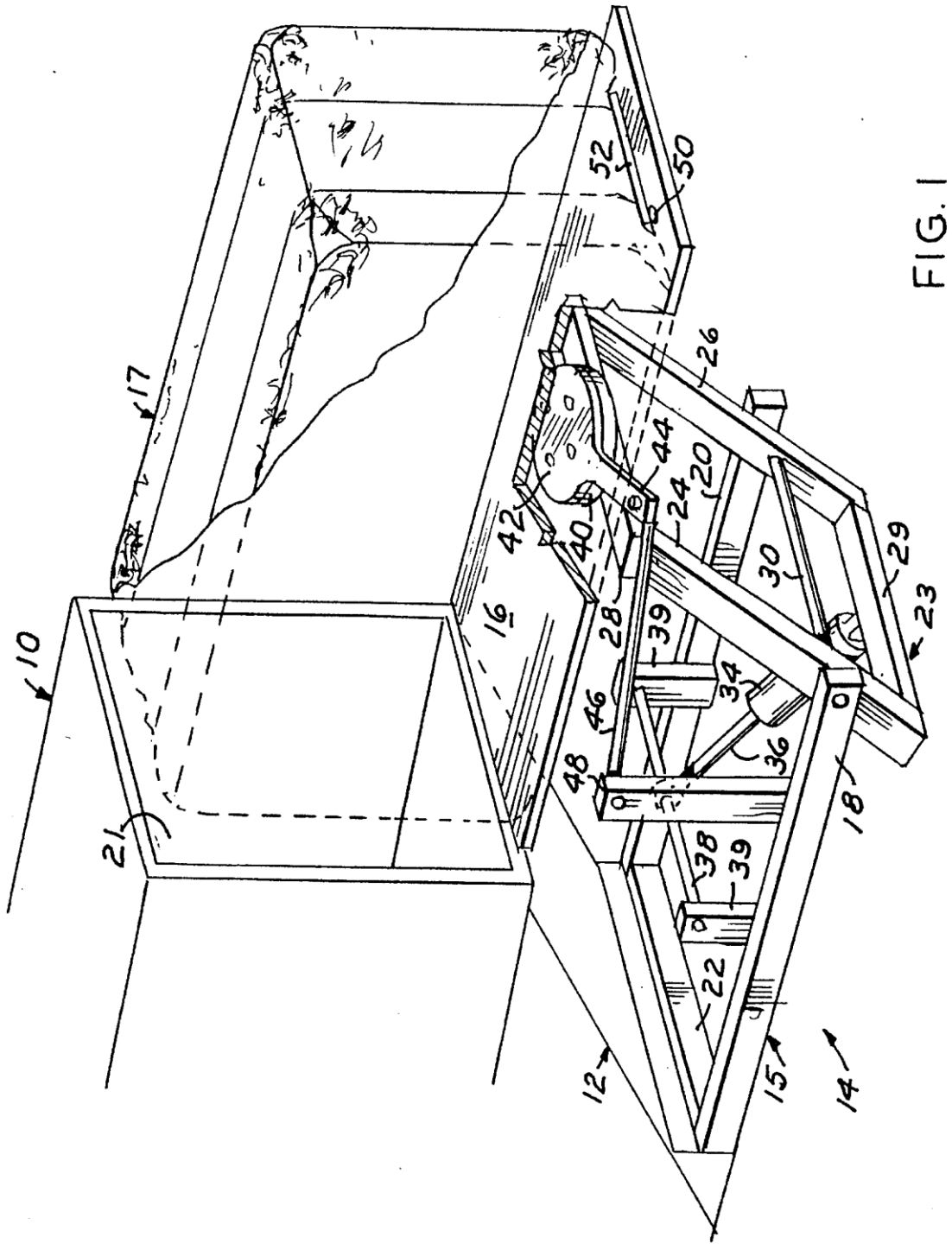

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FIG. 1

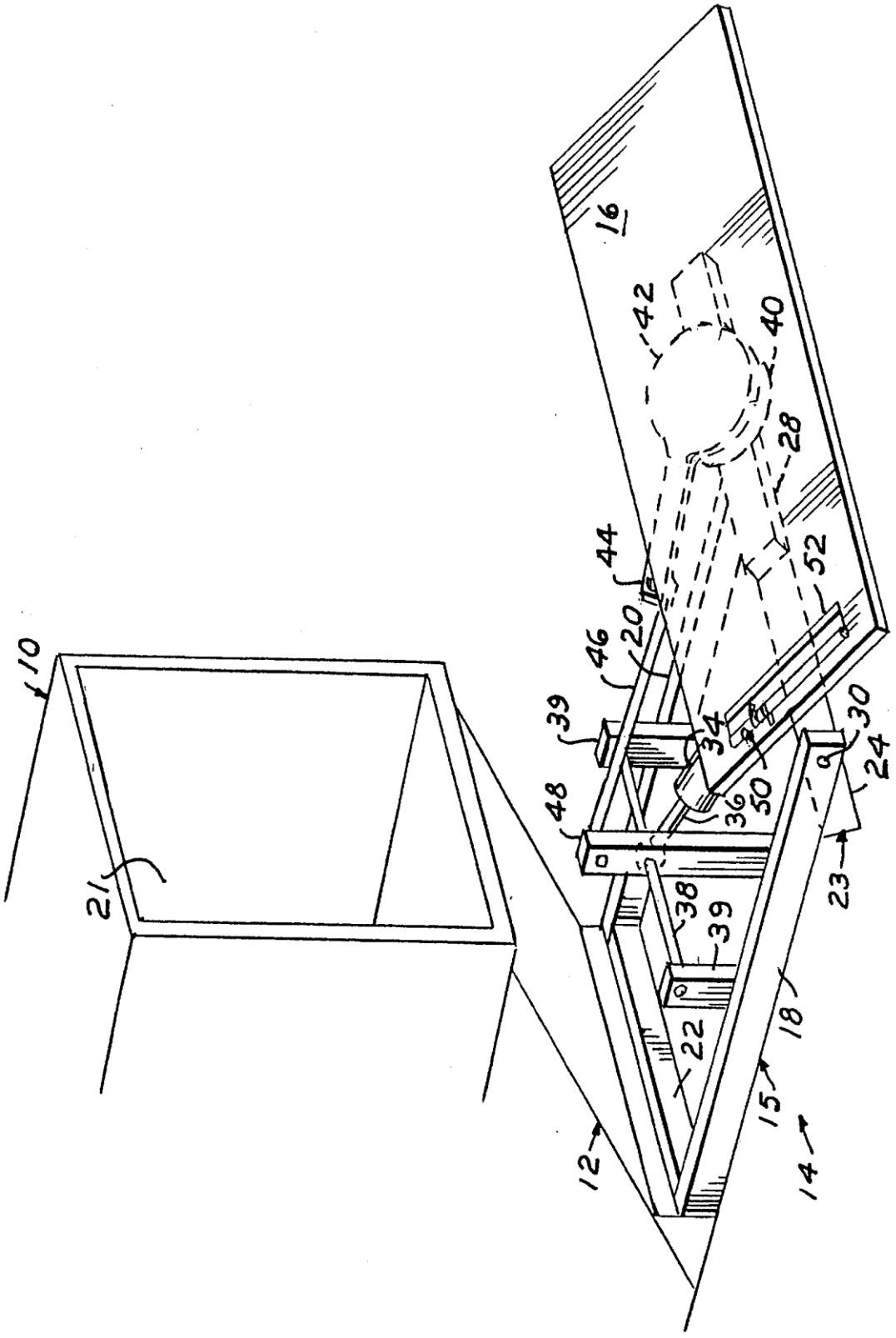
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FIG. 2

JUMBO BALE ROTATING TABLE FOR A HAY BALER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to hay balers forming relatively large size rectangular hay bales, for example, 4×4×8 feet and more particularly to a turntable for angularly rotating a bale 90° about its longitudinal axis as it leaves a baler chamber.

Rectangular jumbo hay bales which may approach a ton or more in mass are conventionally discharged longitudinally from the rearward end of a baler chamber which is an inconvenient position for the bale to be picked up by a bale loader and moved to a place of storage off the meadow or field. This invention provides an apparatus which is attached to the baler and performs the bale rotating function.

2. Description of the Prior Art

The prior art bale pick up, rotating and stacking apparatus generally relates to conventional small size bales of approximately 16×16×48 inches in length.

U.S. Pat. No. 3,497,085 issued Feb. 24, 1970 to Jay et al for BALE ELEVATOR CHUTE CONSTRUCTION and U.S. Pat. No. 4,150,756 issued Apr. 24, 1979 to Butler for BALE WAGON are believed representative of the state-of-the-art. The apparatus of each of these patents pick up a hay bale lying on one of its sides, lengthwise relative to the path of travel, as it leaves a baler and the path of travel of the bale pick up wagon which pulls the bale up a chute to a stack position, rotating the bale or bales as necessary to form tied tiers of a stacked block of such hay bales. These and other prior art patents are believed incapable of handling jumbo size hay bales. Jumbo size hay bales are picked up singularly and moved to a place of storage in side by side relation rather than being stacked, as is common with the smaller size hay bales.

SUMMARY OF THE INVENTION

A hay bale turntable having a support frame is connected with the rearward frame end .of a hay baler. The frame includes a pair of arms pivoting vertically about a horizontal axis and supports a platform substantially horizontal and parallel with the bottom wall of a rearwardly open hay baler chamber.

The platform longitudinally receives a jumbo size hay bale when discharged from the baler chamber. Rearward movement of the hay bale triggers a spring return fluid pressure pilot valve which actuates a cylinder to pivot the arms rearwardly and downwardly. A tether connecting the platform with the support frame angularly rotates the platform substantially 90° about its central axis as the platform is lowered toward the surface of the earth. Depositing the bale on the surface of the earth releases the fluid pressure pilot and activates a fluid pressure cylinder to extend its piston rod and elevate the arms and platform to bale receiving position behind the baler chamber.

The principal object of this invention is to provide a turntable for angularly rotating a jumbo size hay bale substantially 90° and dispose its longitudinal axis transverse to the direction of travel of a hay baler while lowering the bale from a bale chamber exit to the surface of the earth without damage to the hay bale.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a fragmentary isometric view of the bale turntable illustrating a hay bale on a platform by solid and dotted lines; and,

FIG. 2 is a similar isometric view illustrating the platform in bale rotated and lowered position, the bale being omitted for clarity.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Like characters of reference designate like parts in those figures of the drawings in which they occur.

The reference numeral **10** indicates the rearward open end portion of a bale chamber and adjacent frame **12** in turn supporting a bale turntable **14**.

The turntable **14** comprises a rigid frame means **15** supporting an elongated bale receiving platform **16** extending horizontally rearward from the bottom surface of the bale chamber **10** for receiving a jumbo size hay bale **17** longitudinally discharged from the bale chamber.

The support frame means **15** comprises a pair of parallel side rails **18** and **20** connected at their forward ends by an end member **22** secured to the baler frame members **12** for supporting the side rails **18** and **20** in a rearwardly projecting substantially horizontal position and in underlying relation with respect to the rearward opening **21** of the baler chamber.

A pair of parallel rearwardly and upwardly inclined arm means **23** including a pair of spaced-apart arms **24** and **26**, connected at their upper and lower ends by cross members **28** and **29**, are pivotally supported at their depending end portions by an axle **30** projecting horizontally through the rearward end portions of the frame side rails **18** and **20** for vertical pivoting movement of the arms about the horizontal axis of the axle **30**.

A fluid pressure operated cylinder **34** has its piston end connected with the depending cross member **29** and its piston rod **36** connected with an anchor rod **38** extending transversely of the support frame **15** between a pair of posts **39** respectively secured to the frame side rails **18** and **20** for pivoting the upper end portions of a pair of arms **24** and **26** toward and away from the surface of the earth, as presently explained.

A bearing means **40** is centrally interposed between the top cross member **28** and the undersurface of the platform **16**. The bearing means **40** includes a bearing plate **42** rigidly secured to the platform **16** and having an arm **44** projecting laterally beyond one side of the platform **16**. An elongated tether rod **46** is pivotly connected at its respective end portions, as by universal joints not shown, with the end portion of the bearing arm **44** opposite the bearing **40** and the upper end of a standard **48** secured to the frame side member **18** intermediate its ends.

A spring return fluid pressure pilot valve has its push button **50** projecting above the top surface of the platform end portion opposite the baler chamber is triggered for actuating the pressure cylinder **34** for pivoting the arm means **23** and lowering the platform **16**, as presently explained, by the bale **17** depressing a trigger panel **52** normally spring biased upwardly out of contact with the pilot push button **50**.

OPERATION

Operation is believed obvious from the above description. Briefly stated, assuming the turntable apparatus **14** has been installed as described hereinabove and a bale **17** is not on the platform **16**, forward movement of the baler forms a hay

bale **17** which is projected rearwardly out of the bale chamber opening **21**. The rearward end portion of the bale **17** depresses the trigger panel **52** and the pilot valve push button **50** to actuate the pressure cylinder **34** which pivots the upper end portion of the arm means **23**, platform and hay bale toward the surface of the earth. Simultaneously with this movement the tether rod **46** angularly rotates the platform **16** and bale **17** about the axis of the bearing **40** disposing the longitudinal axis of the platform substantially parallel with the transverse rearward end of the baler chamber and in spaced relation with respect to the surface of the earth. The mass of the bale moves it off of the platform releasing the trigger panel **52** and pilot push button **50** to permit the cylinder **46** to extend its piston rod and lift the arm means and platform to the position of FIG. **1** and simultaneously the tether rod **46** rotates the platform to its position of FIG. **1** in cooperative alignment rearwardly of the baler chamber.

Obviously the invention is susceptible to changes or alterations without defeating its practicability. Therefore, I do not wish to be confined to the preferred embodiment shown in the drawings and described herein.

I claim:

1. A bale turntable for a hay baler having a baler frame and having a rearwardly open bale discharging chamber, comprising:

bale support frame means secured to the baler frame and projecting horizontally rearward in underlying relation with respect to the bale chamber;

elongated arm means pivotally connected with the support frame for vertical pivoting movement about a horizontal axis toward and away from the surface of the earth;

a platform supported by said arm means and having an elongated top surface extending rearwardly in cooperative aligned bale receiving relation with respect to the bale chamber;

bearing means connected between said platform and said arm means permitting angular rotative movement of said platform relative to said arm means;

fluid pressure means including a cylinder for pivoting said arm means toward and away from the surface of the earth in response to a hay bale on said platform; and,

tether rod means extending between and connected with the platform and said support frame permitting angularly rotating said platform substantially 90° about a vertical axis and relative to the arm means during movement of the arm means toward and away from the surface of the earth.

2. The bale turntable according to claim **1** in which the fluid pressure means further includes:

a fluid pressure pilot valve push button projecting above the platform top surface opposite the bale chamber; and,

a trigger panel pivotally secured to the platform top surface for depressing the push button and activating said cylinder in response to a hay bale overlying the platform and trigger panel.

3. The bale turntable according to claim **2** in which the arm means includes:

an axle extending transversely with respect to the direction of hay baler travel and horizontally supported by the support frame;

a pair of spaced-apart arms journalled by respective end portions of said axle; and,

upper and lower cross members extending between and connected with said arms.

4. The bale turntable according to claim **3** in which the bearing means further includes:

a bearing secured to said upper cross member, said bearing having a top plate secured to the platform and having a bearing arm projecting latterally of said platform.

5. The bale turntable according to claim **4** in which the support frame means includes:

a pair of laterally spaced-apart side rails having forward end portions secured to said baler frame and having rearward end portions supporting said axle.

6. The bale turntable according to claim **5** in which the tether rod means includes:

an upright standard secured at one end portion to one said side rail; and,

an elongated rod pivotally connected at the other end portion with said standard and the bearing plate arm.

7. The bale turntable according to claim **6** in which the fluid pressure means includes:

a pair of posts secured to said side rails in transversely aligned relation;

an anchor rod extending between said posts; and,

said cylinder including a fluid pressure operated cylinder having a piston rod at one end pivotally secured to said anchor rod and having its end other end pivotally secured to said lower cross member.

* * * * *

Appendix C

US006033172A

United States Patent [19]

Simon

[11] Patent Number: 6,033,172

[45] Date of Patent: Mar. 7, 2000

[54] **BALE TURNING APPARATUS**

[75] Inventor: **Richard L. Simon**, Wichita, Kans.

[73] Assignee: **Maize Corporation**, Maize, Kans.

[21] Appl. No.: **09/253,421**

[22] Filed: **Feb. 19, 1999**

[51] **Int. Cl.**[7] **A01D 90/00**

[52] **U.S. Cl.** **414/24.5**; 414/482; 414/483; 414/911

[58] **Field of Search** 414/24.5, 789.7, 414/111, 911, 477, 478, 482, 483; 298/9

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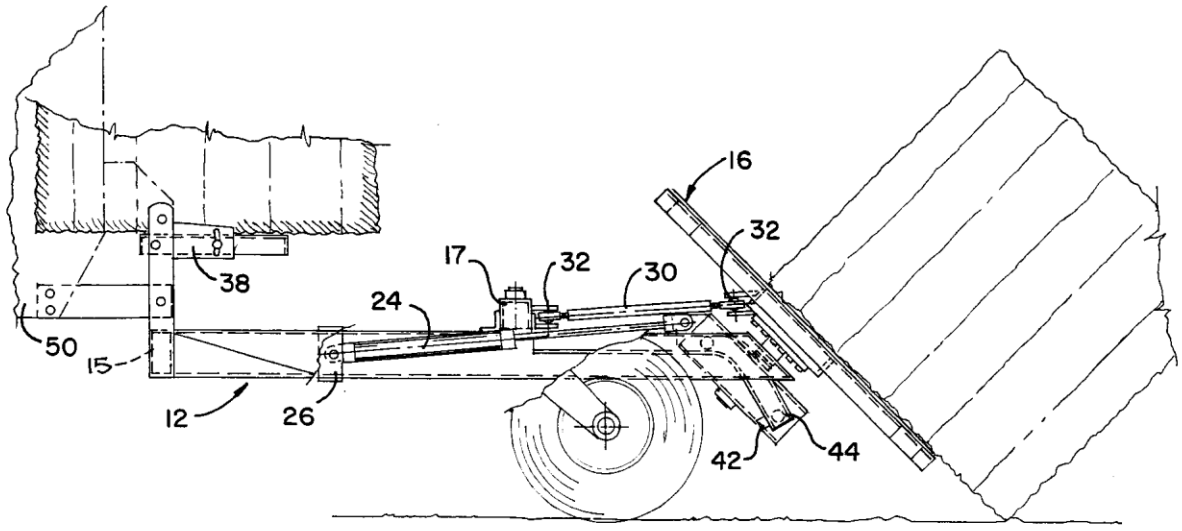
Primary Examiner—Douglas Hess

Attorney, Agent, or Firm—Edward L. Brown, Jr.

[57] **ABSTRACT**

The present invention provides a turning apparatus for receiving large bales from a baler, the apparatus includes a table for receiving the large bales which turns the bale ninety degrees from its original position as it exits from a baler and then tilts the table downward thus rolling the bale off the table. The table angle and its turning speed are adjustable for varying the position in which it is deposited off of the table.

5 Claims, 3 Drawing Sheets



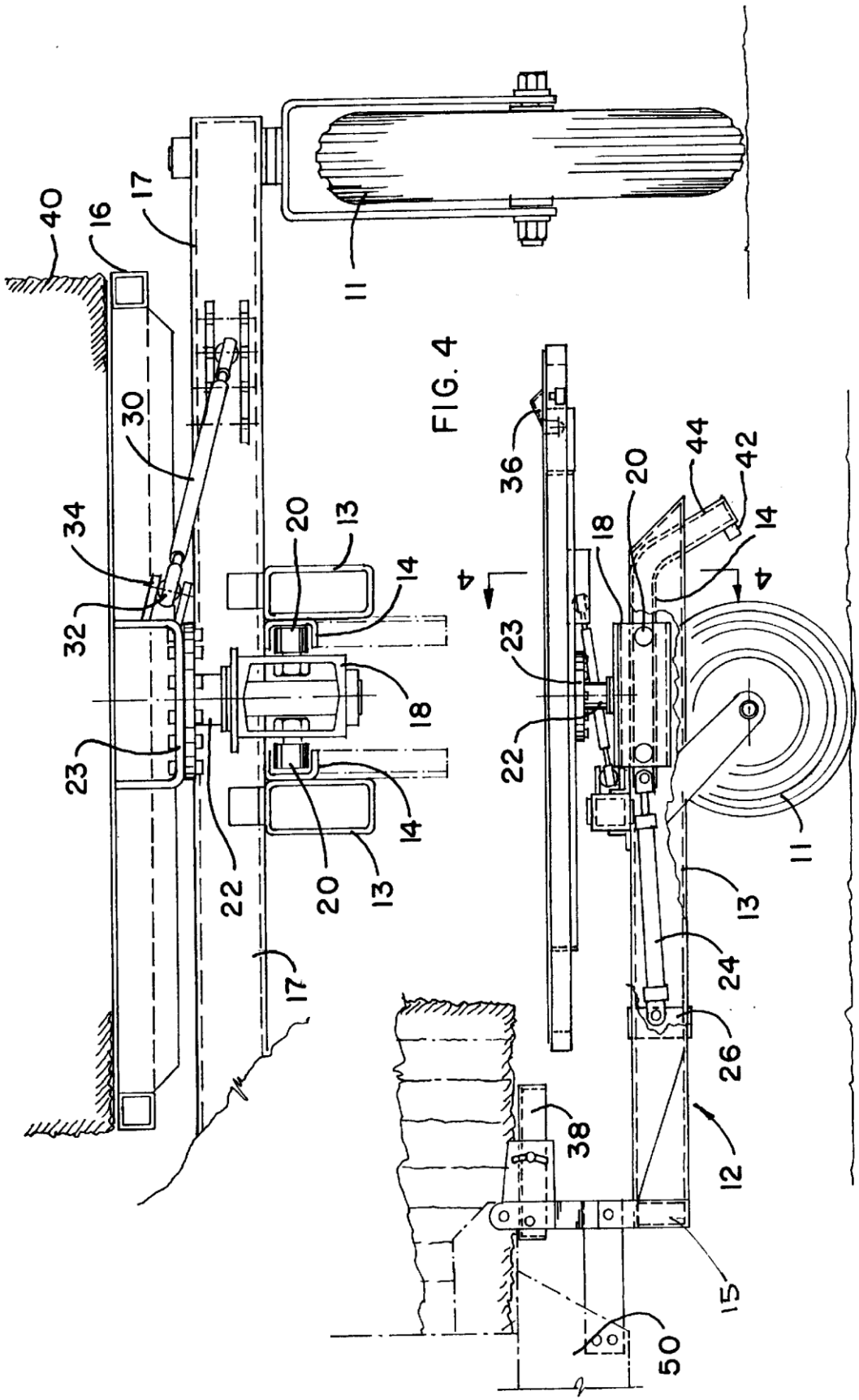

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FIG. 4

FIG. 1

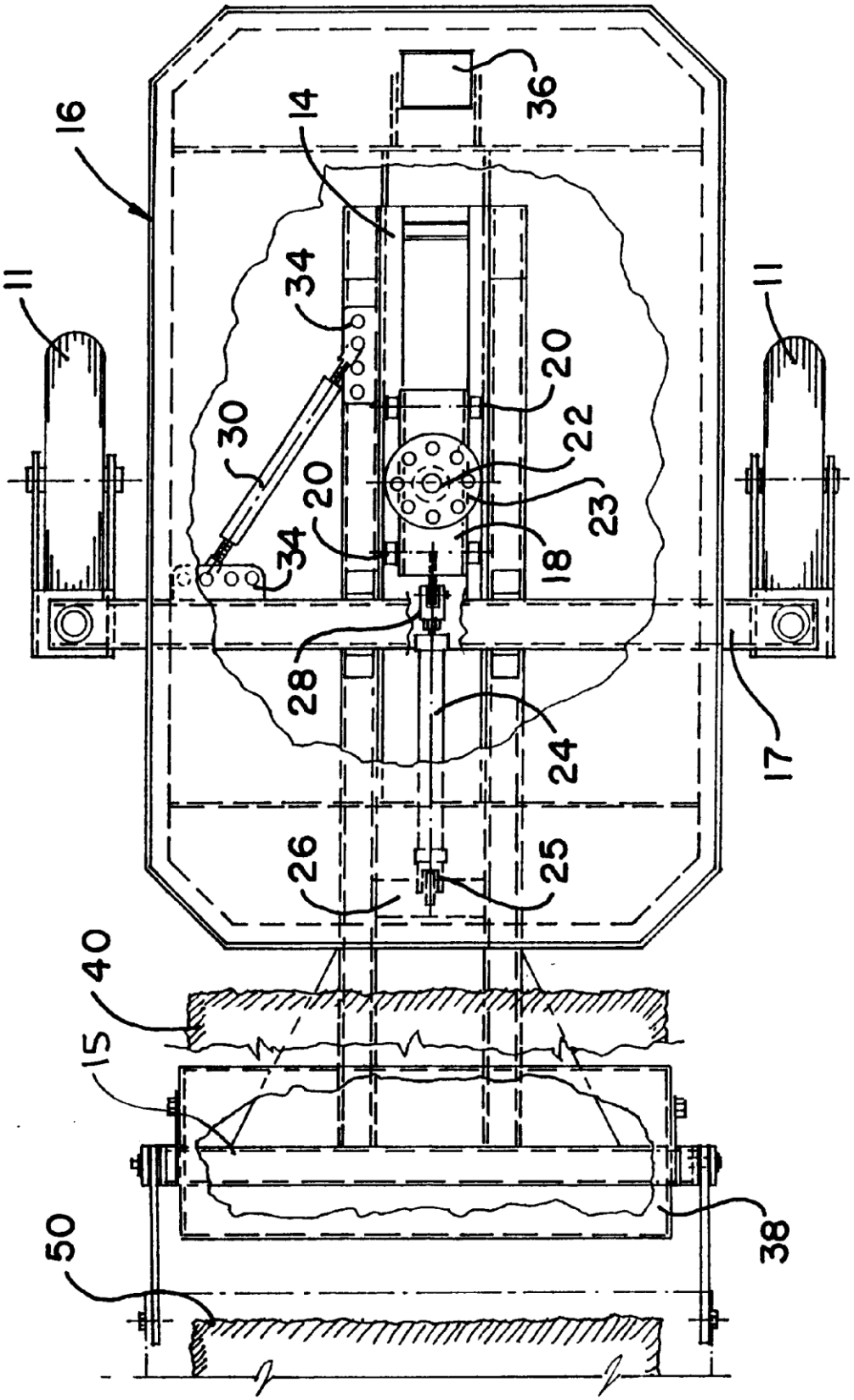

FIG. 2

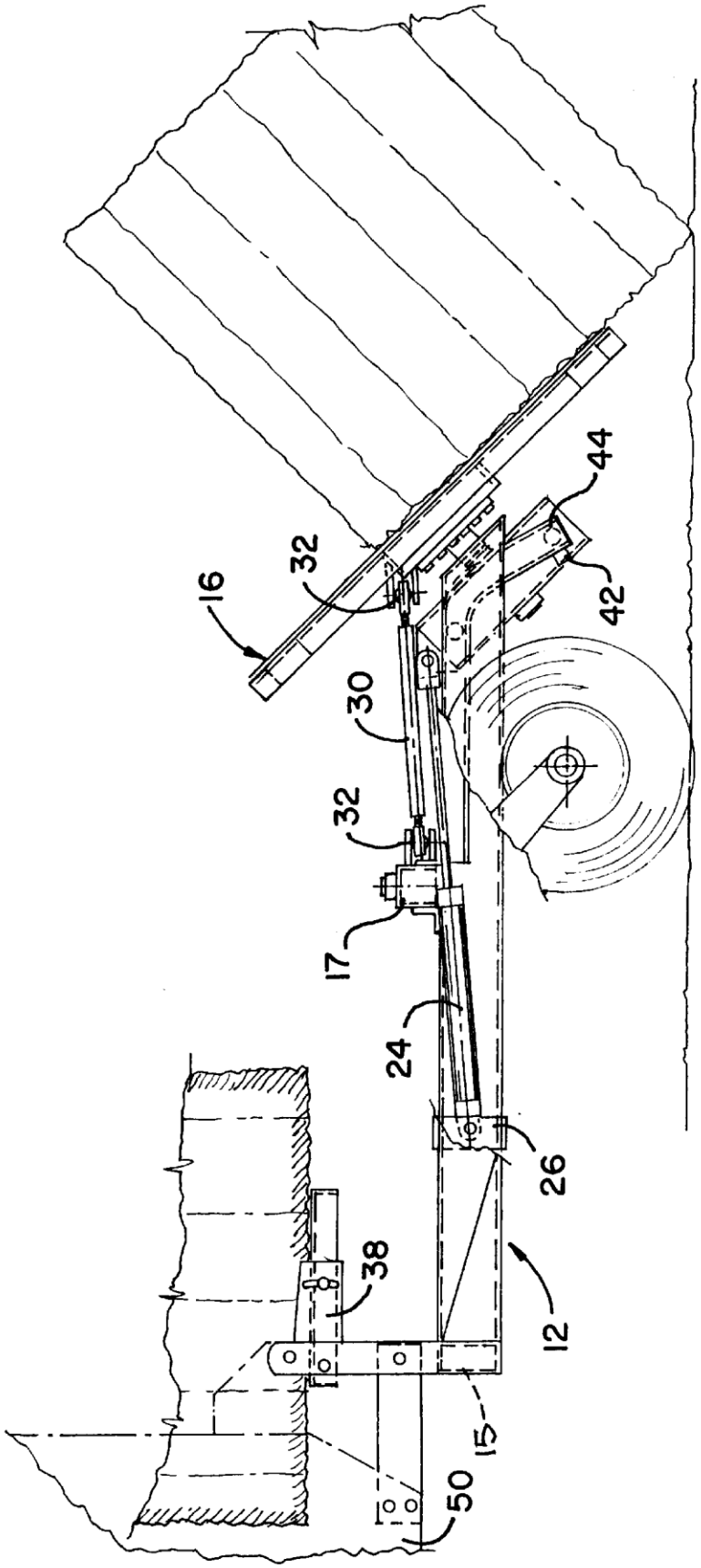

FIG. 3

BALE TURNING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates generally to large bale handling devices and, more particularly, to a bale discharge table which trailers behind the discharge chute of a baler to rotate the bale 90° from its discharge chute while tilting the table sufficiently to roll the bale onto the ground either off or on its bale twines.

Historically since the beginning of baling of forage crops, the size of bales has gradually increased to what we have today which are either large cylindrical round bales or square bales which can weigh between 600 and 2000 pounds. Since the size and weight of these large bales do not permit them to be handled by manual labor, various mechanical means for handling the bales have been developed. While there are several types of bale handling devices available, most of them involve a multiple spearing type device mounted on either a tractor front end loader or a 3-point hitch which drives one or more spears into the side of the bale and then lifts the bale for either transport or loading. These bale loaders follow the baler as it moves through the field and since the bales are not ejected with the sides of the bale facing the loaders, it requires the bale loader, each time it engages a bale to swing off to the side, making a wide turn and engage the side of the bale before it can be lifted. This extra movement in the field is a waste of energy and time which has encouraged equipment manufacturers to develop a turning apparatus to turn the bales 90° as they exit the outlet chute of the baler such as taught in U.S. Pat. No. 4,162,135 to Seymour. The device in the above-mentioned patent is utilized with round rather than square bales and it achieves the turning by dragging one end of the bale 90° after it is already on the ground. The apparatus of the present invention rotates the big square bale while it is still on a table before it is dumped onto the ground.

In the prior art, most balers of either round or square bales wrap their bales with twine in a vertical plane so as the bales exit the outlet chute the twine is on the top and bottom of the bale which is undesirable to some for various reasons. To keep the bales off their twine, the bales were supported on one side at the exit chute thus causing them to roll from the unsupported side 90° as they hit the ground. This method is taught in the following prior art patents of Matthews U.S. Pat. No. 2,853,171; Shepley et al U.S. Pat. No. 3,161,008; Tufts U.S. Pat. No. 3,243,028; and Girard U.S. Pat. No. 5,024,152.

SUMMARY OF THE INVENTION

The present invention rolls its bales off the twines differently than the above-mentioned patents by tilting its table downward approximately 45° and rolling the bale onto the ground. Prior to rolling the bale onto the ground, the bale is initially moved onto a rotating table which turns the bale through 90° before it is slid to the ground, thus allowing the side of the bale to be directly engaged by a loader without having to maneuver the loader.

The principal object of the present invention is to provide a turning apparatus for large square bales which turns the bale 90° from its position exiting the baler and then tilts the table downward thus rolling the bale off the table and off its twines.

Another object of the invention is to provide a bale turning apparatus wherein the bale can be deposited on the ground either on its twines or off its twines by adjusting the table angle and table speed as the operator may choose.

A further object of the present invention is to provide a bale turning apparatus which is fully automatic with a discharge function which can vary to suit the operator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of the bale turner with the table in its receiving position;

FIG. **2** is a top plan view of the bale turner with the table in its receiving position;

FIG. **3** is a side elevational view of the bale turner with its table in its ejecting position; and

FIG. **4** is a partial sectional view taken along lines **4**—**4** of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The bale turning apparatus of the present invention is generally described as reference numeral **10** as shown in all the Figures. The bale turner **10** attaches to the rear of a baler through bolts **52** which allows the bale turner **10** to pivot about a horizontal axis with the baler. The baler is not shown in the drawing; however, the baler outlet chute **50** is shown in FIGS. **1** and **2** with a plurality of bales **40** and **40'** moving there along.

The bale turner **10** comprises a frame **12** riding on a pair of castered wheels **11** with the front portion of the frame **12** attached to the baler through lateral cross member **15**. Mounted on frame **12** is a turn table **16** which is roughly 4 feet by 8 feet, the size of the bale, and is pivotally mounted to carriage **18** through a pivot pin **22** in the center of the table **16**. The carriage **18** having four wheels **20**, rides in a pair of rails **14**, which are channel shaped, containing the four wheels **20**. The rails **14** allow only lineal longitudinal movement of the carriage **18**. The rails **14** are attached to the inside of longitudinal frame members **13** as best seen in FIGS. **1** and **2**. The carriage **18** supporting table **16** is moved through the action of a double acting hydraulic cylinder **24** which is mounted on its left end as seen in FIG. **1** to cross member **26** and at its rod end to a lug **28** on carriage **18**. Both ends of cylinder **24** are conventional clevis pivoted connections thereby permitting carriage **18** to rotate downward as carriage **18** moves into the down turned portion **44** of rails **14** as seen in FIG. **1** and FIG. **3**. The angle of the down turned portion **44** exceeds 45° and thus permits the table **16** to be tilted at variable angles of tilt depending on how far carriage **18** is allowed to advance. In FIG. **3**, carriage **18** is shown at its maximum angle of tilt with a table angle of approximately 45°. That angle of tilt is controlled by limit switches **42** positioned on rail **14**.

While the tilt of table **16** is achieved by carriage **18** engaging the down turned portion **44** of the rail, the rotation of table **16** is affected by rigid link **30**. When viewing FIG. **2**, it can be seen that link **30** pivotally attaches to a mounting bracket **34** on lateral cross member **17** of frame **12** while the opposite end of link **30** pivotally attaches to the underside of table **16** through a similar mounting bracket **34**. Mounting brackets **34** illustrate multiple mounting points which can be adjusted to change the turning angle of table **16**. The turning angle of table **16** is also affected by how far carriage **18** extends from its FIG. **2** position. Both ends of link **30** include a ball joint type clevis thus allowing the joints to move in two planes as shown in FIG. **4**, which is taken along Line **4**—**4** of FIG. **1**.

Carriage **18** includes a journal for pivotally supporting pin **22** which in turn is attached to table **16** through a flange **23**,

as seen in FIG. **2**. The hydraulic power source for moving table **16** which is not shown can be supplied from a power source on the baler or tractor which is conventionally done in many applications.

Located at the rear edge of table **16** is an actuating switch **36** which is made as the bale comes in contact therewith for initiating the turning and depositing of the bale on the ground as described hereafter.

OPERATION

As the baler moves across the field and bales the particular forage crop, the bales **40** and **40'** are slowly moved down the outlet chute **50** by bale guide **38** onto table **16**. As bale **40** reaches its centered position on table **16**, switch **36** is actuated causing cylinder **24** to extend at a preselected rate which moves carriage **18** rightwardly as seen in the drawings towards its fully extended position as seen in FIG. **3**. As the carriage initially moves, link **30** will cause the table to rotate in a counterclockwise direction as seen in FIG. **2** so that the upper left corner of table **16** as seen in FIG. **2** clears the upstream bale before the table begins to tilt.

As the front wheels **20** in carriage **18** begin to engage the down turned portion **44** of the rails, the table will begin to tilt downward and will complete its tilt once a limit switch **42** is engaged. Once the angle of tilt exceeds the friction between the table and the bale, the bale will slide to the ground either on or off its bale twines depending upon the choice of the operator by way of increasing or slowing the rate of cylinder movement.

While the preferred structure in which the principles of the present invention have been incorporated is shown and described above, it is to be understood that invention is not limited to the particular structure presented in the drawings and specification. In fact, different means may be employed in the practice of the broader aspects of the invention such as the two moving functions of the table. The scope of dependent claims is intended to encompass all obvious changes in the details, materials and arrangement of parts which will occur to one skilled in the art upon reading this disclosure. It is also to be understood that the teachings of the present invention are also applicable to a round bale baler.

Having described the invention, what is claimed is:

1. A bale turning apparatus for use with a bale-forming machine having a bale outlet chute aligned with the front of the turning apparatus, the apparatus comprising:

a frame attached to the baler;

a turning table pivotally mounted at its center for rotation in a horizontal plane for positioning in alignment with the outlet chute;

at least one horizontal rail member longitudinally positioned on said frame having a forward end and a down turned portion at the rear end thereof;

a wheel-mounted carriage mounted on said rail having a pivot pin thereon for pivotally supporting said table;

a linear actuator supplied by a power source attached at one end to the frame and the other end to the carriage for movement of the carriage along said rail to the down turned portion;

a rigid link pivotally connecting the frame to the underside of said table offset from the table pivot pin whereby as the table and carriage move along the rail the table rotates through an angular path;

stop means on the frame which stops the carriage on the down turned portion of the rail after the table has been rotated and tilted causing the bale to slide to the ground.

2. A bale turning apparatus as set forth in claim **1** wherein the frame is a wheel supported trailer for pivotally hitching to the baler, and the table lies in a common plane with the outlet chute.

3. A bale turning apparatus as set forth in claim **1** wherein the stop means has a plurality of stopping points on the down turned portion whereby the table can be stopped at different tilting angles.

4. A bale turning apparatus as set forth in claim **1** including sensing means in the table to sense the position of the bale on the table which actuates the linear actuator to rotate, tilt and slide the bale thereon onto the ground.

5. A bale turning apparatus as set forth in claim **1** wherein the stop means has a plurality of stopping points on the down turned portion whereby the table can be stopped at different tilting angles and sensing means in the turning table to sense the position of the bale on the table which actuates the linear actuator to rotate, tilt and slide the bale thereon onto the ground.

* * * * *

Appendix D

List of Tables

Appendix E

List of Figures

Appendix F

Bailey Hydraulic Catalog. 2012. Issue 279, 2nd ed. Page 27.

Di Cristoforo, R., Sweatman, P. (2004). Further testing and simulation of hay bale loading on semi-trailers (RIRDC Publication No 04/124). Rural Industries Research and Development Corporation. Retrieved October 21, 2012 from https://rirdc.infoservices.com.au/down**loads**/04-124

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OnlineMetals.com. *Hot Rolled Mild Steel Plate A36.* Retrieved November 21, 2012 from http://www.onlinemetals.com/merchant.cfm?pid=9993&step=4&showunits=inches&id=839&top_cat=849

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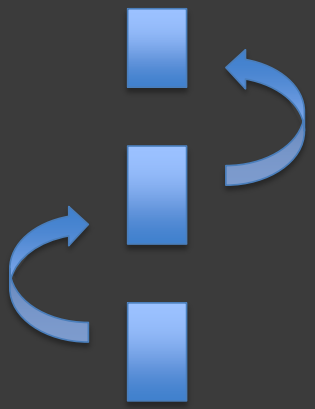
John Boevers
John Morris
Molly Vich
Wes Wegener

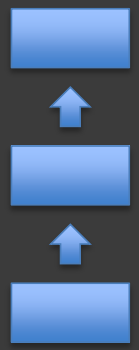
Mission Statement

Our Mission is to provide innovative and economical solutions to the hay and forage industry that will maximize efficiency

Problem Statement

Our team was faced with the task of designing an attachment that would rotate large square bales ninety degrees along the long axis of the bales.





Statement of Work

- This attachment is to turn the bale ninety degrees from its original position
- Also, focus on minimizing the dragging on the bales when released from attachment
  - Reducing soil accumulation on the bale

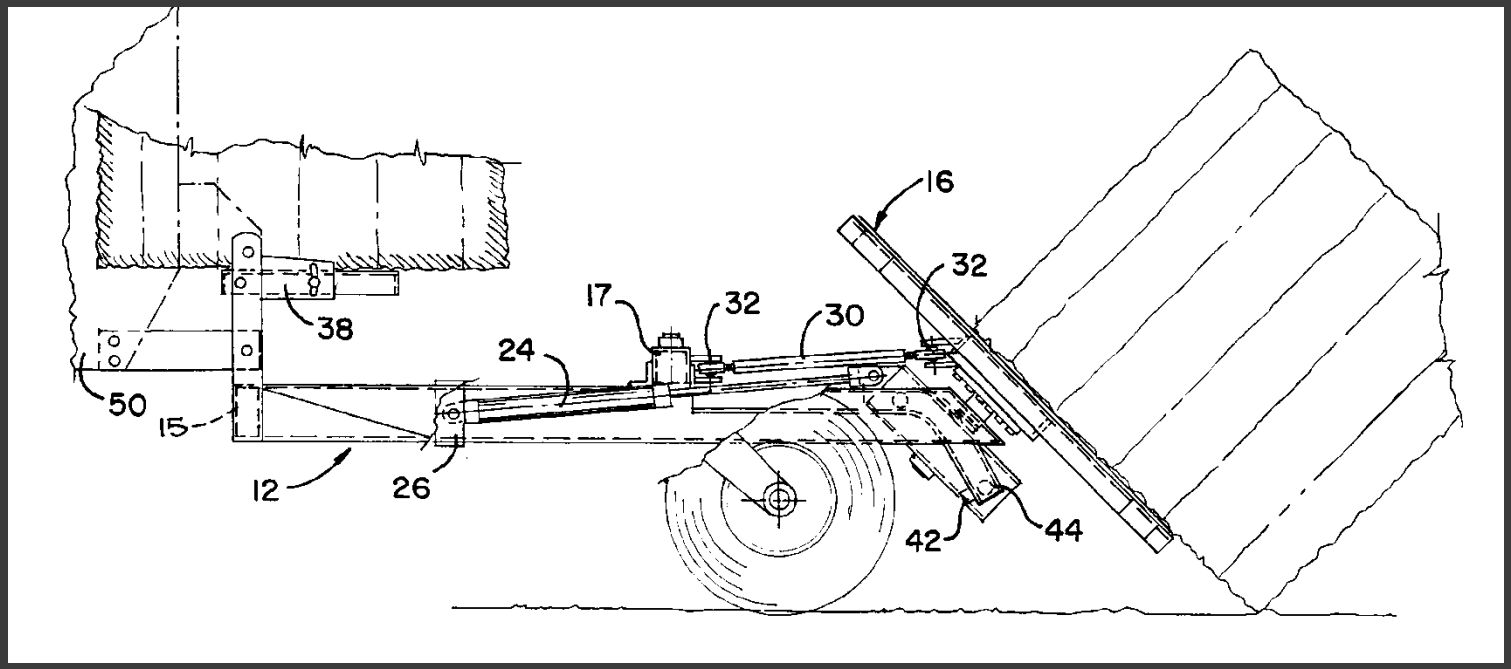
Work Breakdown Structure

- Documentation
  - Literature Research
- Testing
  - Stress/Fatigue Analysis
- Fabrication
  - Model or Prototype
- Design
  - 5 part breakdown

Competitors

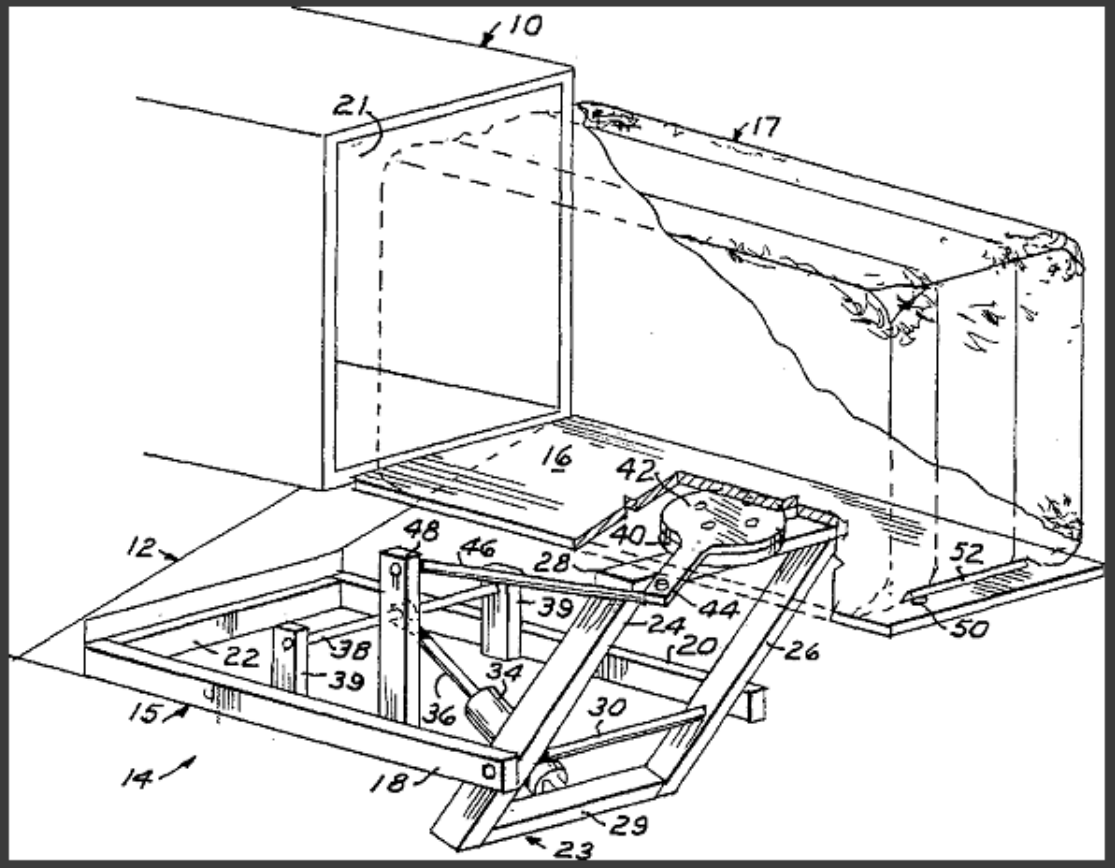
- John Deere
- CNH
- Vermeer
- Krone

Similar Products - Patents



Bale Turning Apparatus (6033172)

Similar Products - Patents



Jumbo Bale Rotating Table for a Hay Baler (5560191)

Similar Products – Vermeer Cornstalk Special

Market Research

- Providing hands on training and experience with new AGCO products is the key marketing philosophy of the company
- Target hay and forage producers will need to see the bale turner in action, to be instructed on how to attach it to a large-square baler and to get a first-hand look at its construction
- North America, Canada, Eastern and Western Europe, New Zealand, Africa, Central and South America
- Commercial Dealerships will be the primary source of marketing for our product

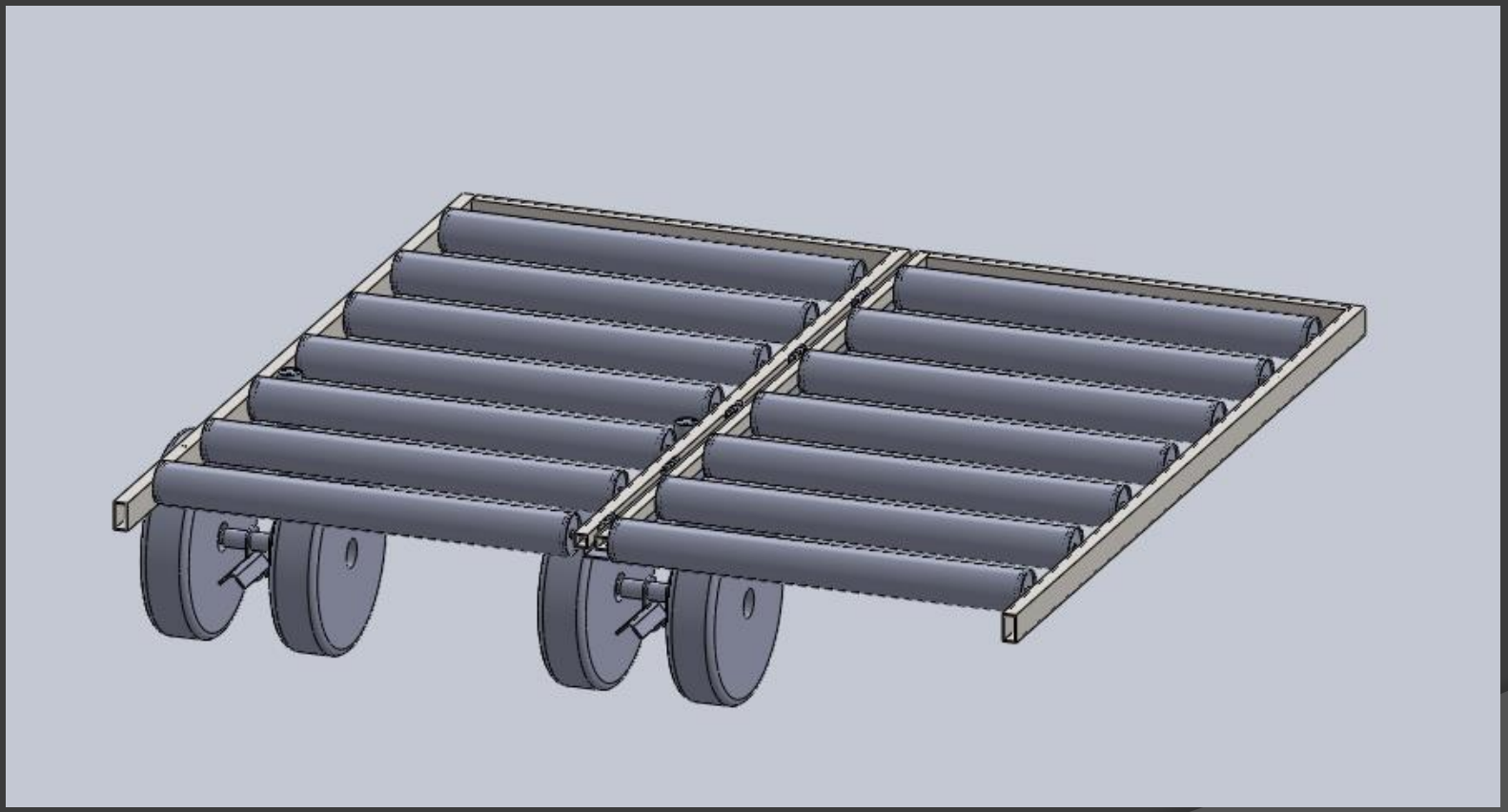
Engineering Specifications

- Bale size 4x4x9 feet
- Max bale weight 3,000 lbs
- Angle of bale chute is 6 degrees to the horizontal
- Distance from chute to ground 41.34 inches
- Baler can produce 70.5 bales per hour
- $\frac{47\ rev}{min} * \frac{1\ flake}{rev} * \frac{1\ bale}{40\ flakes} * \frac{60\ min}{hour}$

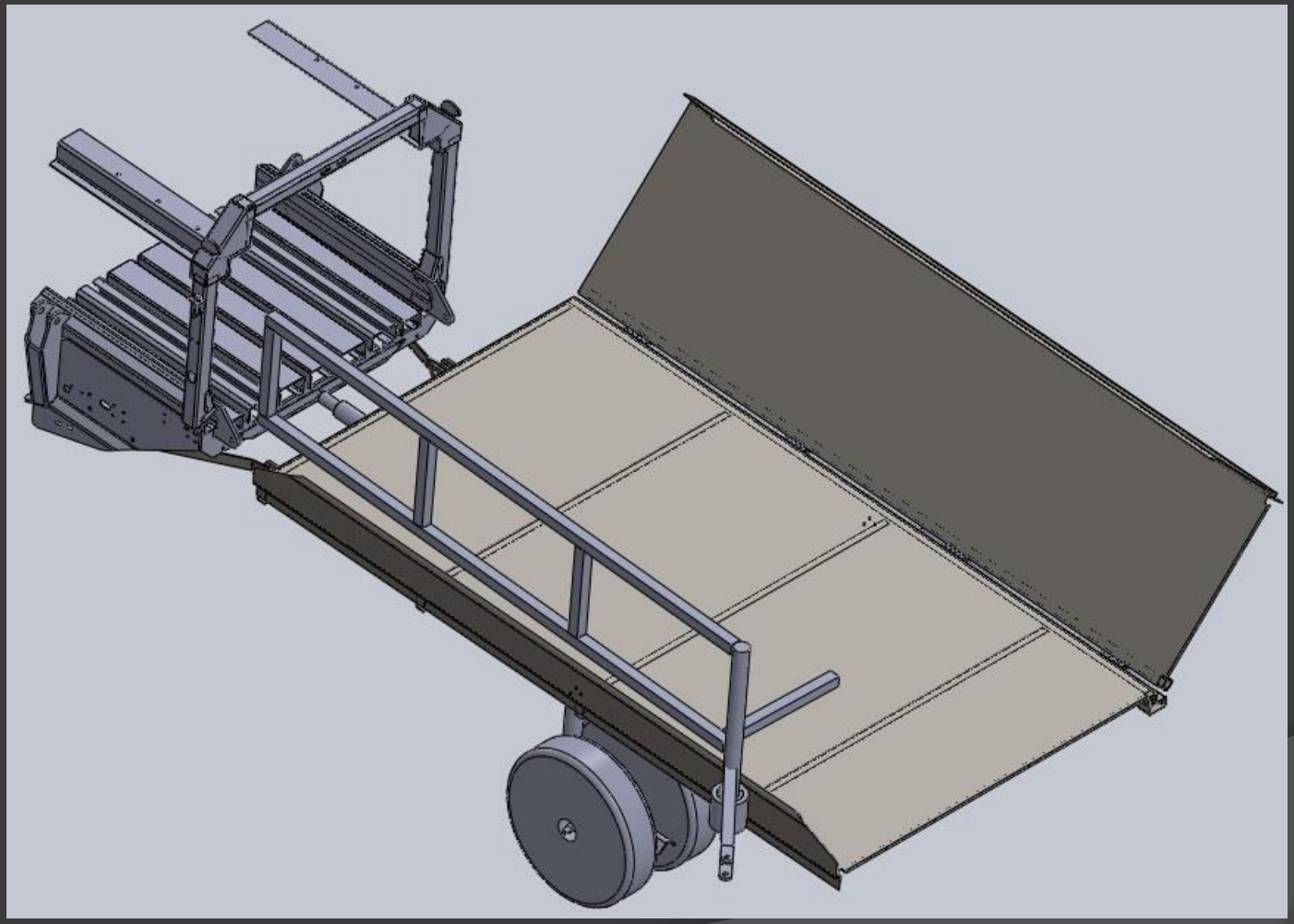
Frame

- Dimensions 10 x 10.5 feet
- Slide
  - Limit switch
    - Located at rear end
- Materials
  - 2x4 tubing, 3/16 inch thick
  - Sheet metal 3/16 inch thick

Roller Option

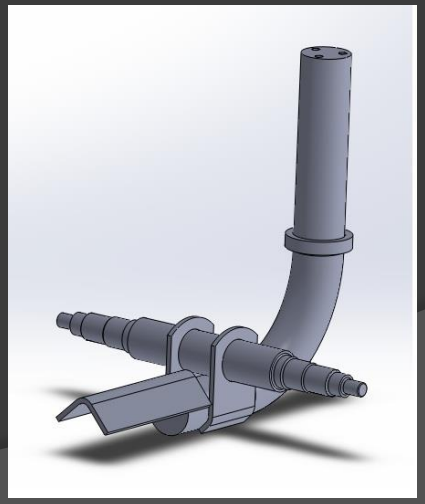


Picture of Frame w/ sheet metal



Axle

- Walking beam axle considered
- Caster wheels
  - Tire size 6.70-15SL, rated at 1610lb each
  - 4 tires



Turning Device

- Lever Arm
  - 2x2 tubing 3/16 inch thick
  - 3 inch steel rod, pivot point
  - Dimensions
    - 2 tubes 1.5 feet apart
    - Length 9 feet

Connection Component

- Hitch will be connected at 3 positions
- 2 extension tabs
- Hook up

Hydraulics

- Wing cylinder
- 2 inch bore, 28 inch retract, 20 inch stroke, column load of 7930 lbs

Hydraulics

- Lever Arm cylinder
- 2.5 inch bore, 44inch retract, 36 inch stroke, column load 6230 lbs
  - $GPM = \frac{\pi * D_p^2}{4} * S * \frac{(\frac{60}{231})}{T_e}$

T_e = Time for extension

S = Stroke

Hydraulics

- Horse Power needed to operate hydraulics for quarter turner

- $hp = \frac{GPM * PSI}{1714}$

Time (s)	GPM(extension)	HP	GPM(retraction)
20	2.3	4.02	1.6
15	3.1	5.43	2.1
10	4.6	8.05	3.2
5	9.2	16.1	6.4
4	11.5	20.1	8
3	15.3	26.8	10.7
2.5	18.4	32.2	12.8

Hydraulic Components

- Hydraulic Hoses
- Pilot controlled check valves

Lever Arm

- Force needed to push bale 2130lbs
  - μ_s=.71, weight of bale 3000lbs

3000lbs * .71 = 2130lbs

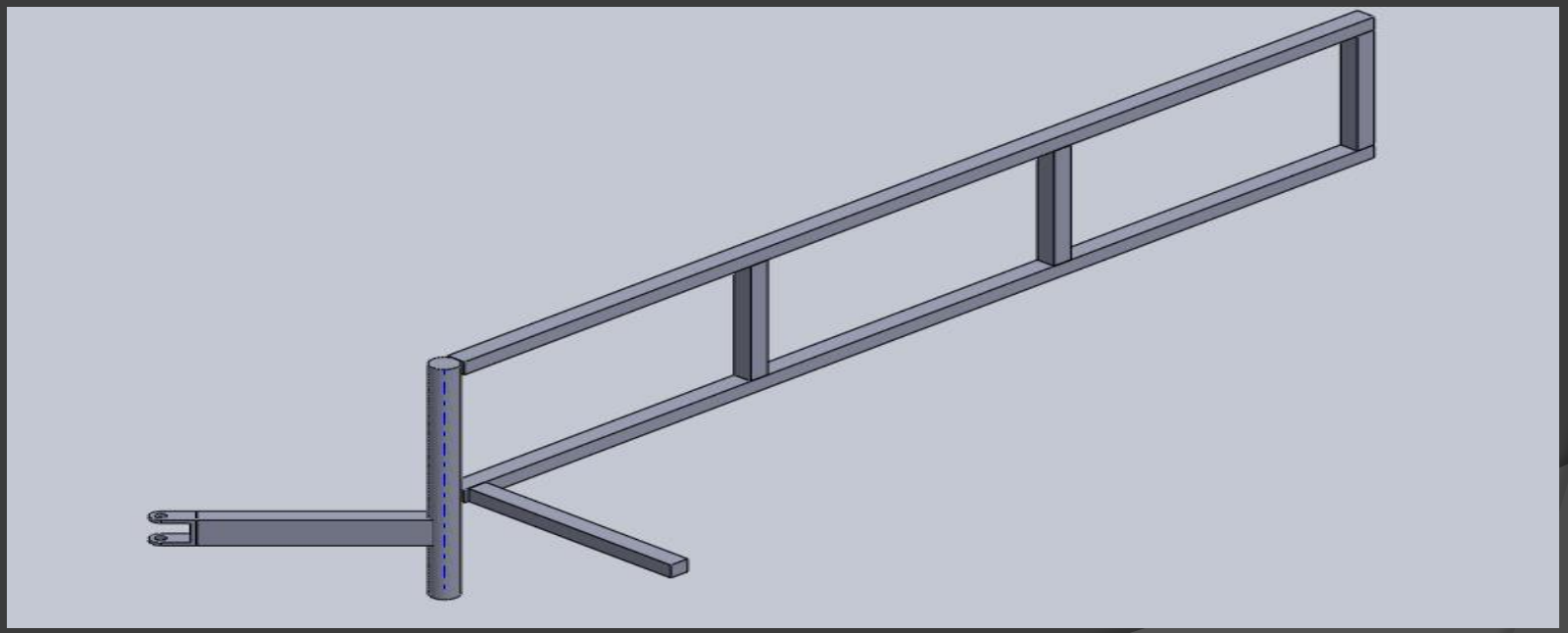
Lever Arm

- Hydraulic cylinder pulls on arm at a 45° angle
- Max force cylinder exerts on bale 4406lbs

$$6230\text{lbs} * \sin(45°) = 4406\text{lbs}$$

Lever Arm

- Hydraulic cylinder is offset 1.41 feet from frame

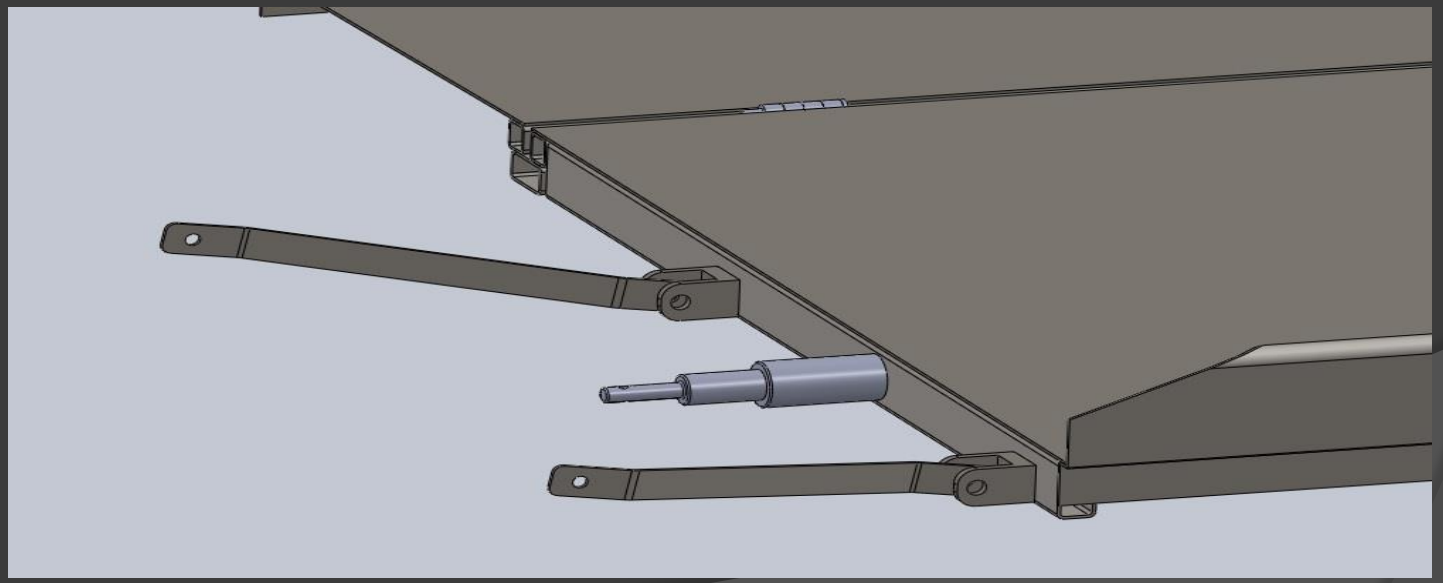


Weight of Attachment

- Estimated weight 5,000lbs
- Tongue will carry some of the load
- Equation used:
  - Weight of all material * quantity of material

Design Concepts - Hitch

- Focus on flexibility for uneven terrain
- Easy hookup to baler



Design Concepts – Bale Turning Mechanism

- Lever Arm
  - Considered hydraulic motor
  - Hydraulic cylinder chosen instead
    - Cylinder 1.5 feet away from swing arm and 5 feet from lever arm pivot
  - Limit switches (2)
    - Pilot controlled check valves regulate flow
    - Allows time for bale to slide off before resetting

Design concepts – Wheels/Suspension

- Considered walking beam axle to compensate for twisting on uneven terrain
  - Made attachment too tall
  - Hitch allowed for simpler design
- Caster wheels

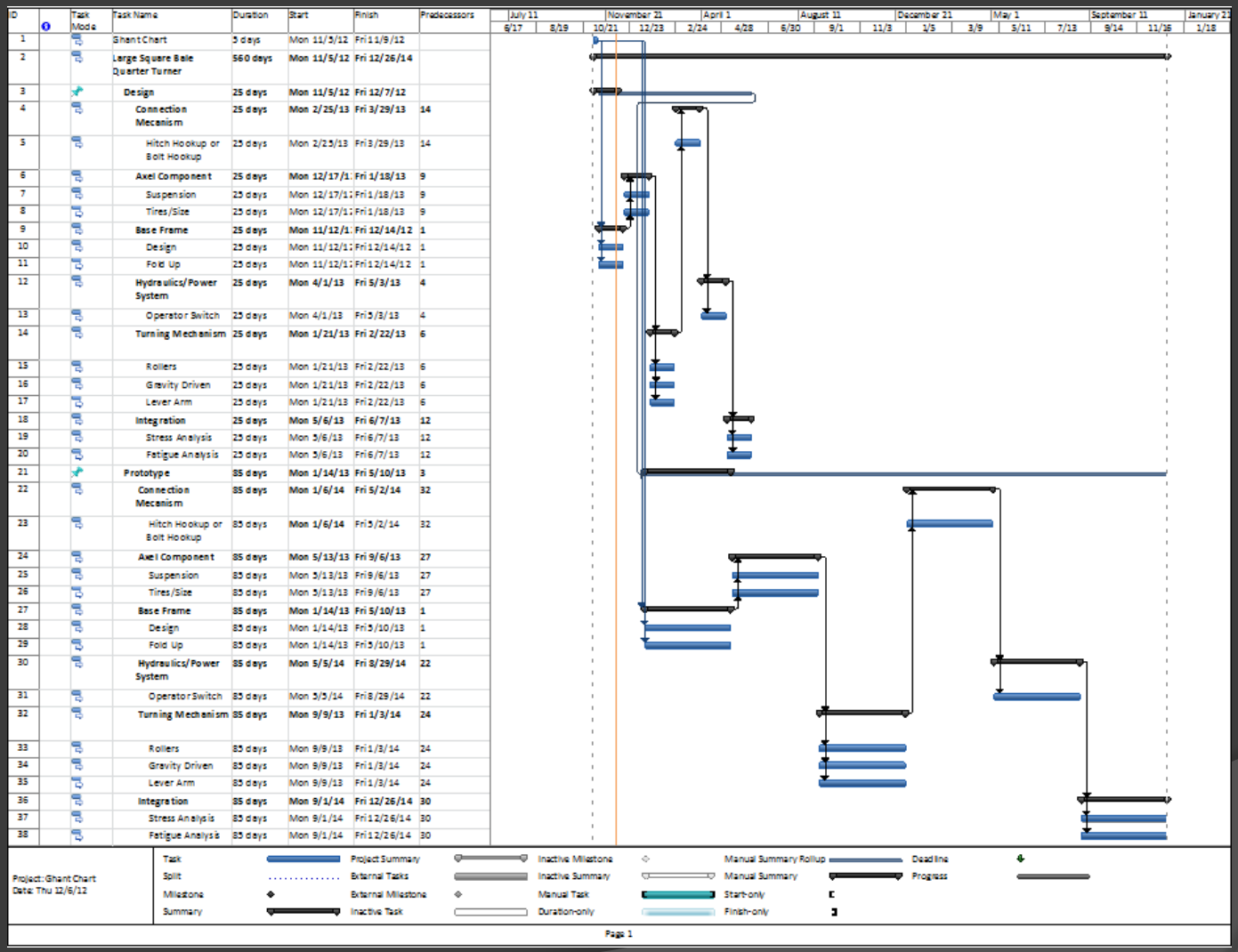
Design Concepts - Materials

- 2x2/2x4 3/16” thick tubing
- 3/16” sheet metal
- Similar to bale accumulator
  - We are only handling 1 bale compared to 3 bales handled by accumulator
  - Safety factor

Design Concepts – Quarter Turner

- Left side
  - 7 ft. wide
  - Swing arm
- Right side
  - 3 ft. wide
  - Fold up for transportation
  - Cylinder pull up
    - 2 in. bore
    - 28 in. retract
    - 20 in. stroke

Project Schedule – Gantt chart



ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Ghant Chart	5 days	Mon 11/5/12	Fri 11/9/12	
2		Large Square Bale Quarter Turner	560 days	Mon 11/5/12	Fri 12/26/14	
3		Design	25 days	Mon 11/5/12	Fri 12/7/12	
4		Connection Mecanism	25 days	Mon 2/25/13	Fri 3/29/13	14
5		Hitch Hookup or Bolt Hookup	25 days	Mon 2/25/13	Fri 3/29/13	14
6		Axel Component	25 days	Mon 12/17/1	Fri 1/18/13	9
7		Suspension	25 days	Mon 12/17/1	Fri 1/18/13	9
8		Tires/Size	25 days	Mon 12/17/1	Fri 1/18/13	9
9		Base Frame	25 days	Mon 11/12/1	Fri 12/14/12	1
10		Design	25 days	Mon 11/12/1	Fri 12/14/12	1
11		Fold Up	25 days	Mon 11/12/1	Fri 12/14/12	1
12		Hydraulics/Power System	25 days	Mon 4/1/13	Fri 5/3/13	4
13		Operator Switch	25 days	Mon 4/1/13	Fri 5/3/13	4
14		Turning Mechanism	25 days	Mon 1/21/13	Fri 2/22/13	6
15		Rollers	25 days	Mon 1/21/13	Fri 2/22/13	6
16		Gravity Driven	25 days	Mon 1/21/13	Fri 2/22/13	6
17		Lever Arm	25 days	Mon 1/21/13	Fri 2/22/13	6
18		Integration	25 days	Mon 5/6/13	Fri 6/7/13	12
19		Stress Analysis	25 days	Mon 5/6/13	Fri 6/7/13	12
20		Fatigue Analysis	25 days	Mon 5/6/13	Fri 6/7/13	12
21		Prototype	85 days	Mon 1/14/13	Fri 5/10/13	3
22		Connection Mecanism	85 days	Mon 1/6/14	Fri 5/2/14	32
23		Hitch Hookup or Bolt Hookup	85 days	Mon 1/6/14	Fri 5/2/14	32
24		Axel Component	85 days	Mon 5/13/13	Fri 9/6/13	27
25		Suspension	85 days	Mon 5/13/13	Fri 9/6/13	27
26		Tires/Size	85 days	Mon 5/13/13	Fri 9/6/13	27
27		Base Frame	85 days	Mon 1/14/13	Fri 5/10/13	1
28		Design	85 days	Mon 1/14/13	Fri 5/10/13	1
29		Fold Up	85 days	Mon 1/14/13	Fri 5/10/13	1
30		Hydraulics/Power System	85 days	Mon 5/5/14	Fri 8/29/14	22
31		Operator Switch	85 days	Mon 5/5/14	Fri 8/29/14	22
32		Turning Mechanism	85 days	Mon 9/9/13	Fri 1/3/14	24
33		Rollers	85 days	Mon 9/9/13	Fri 1/3/14	24
34		Gravity Driven	85 days	Mon 9/9/13	Fri 1/3/14	24
35		Lever Arm	85 days	Mon 9/9/13	Fri 1/3/14	24
36		Integration	85 days	Mon 9/1/14	Fri 12/26/14	30
37		Stress Analysis	85 days	Mon 9/1/14	Fri 12/26/14	30
38		Fatigue Analysis	85 days	Mon 9/1/14	Fri 12/26/14	30

Financial Analysis

Cash Flow Needed for the Quarter Turn Bale Handler				
Production Requirements	**Priced per…**	Quantity	Cost/Unit	Total
2x4x3/16 in. hot rolled steel tubing	foot	38.5	$6.58	$253.33
2x2x3/16 in. hot rolled steel tubing	foot	47.5	$4.16	$197.60
3/16 in. mild steel A36 hot rolled plate	square foot	126	$10.20	$1,285.20
44 in. retract hydraulic cylinder		1	$220.00	$220.00
28 in. retract hydraulic cylinder		1	$169.00	$169.00
tires		4	$63.43	$253.72
miscellaneous parts (hose, pins, pilots, etc)		X	$1,000.00	$1,000.00
Outsourcing Fee (40% markup on the variable costs)		1	$1,478.50	$1,478.50
Labor		Hours	$ per Hour	Total
Welding and Assembly (3 workers, $21/hr.)		24	$21.00	$504.00
Total for Production of One Quarter Turn Bale Handler				$5,361.35
Total Cash Flow Needed (100)		*100 units		**$536,135**

Proposed Budget for Prototype

Proposed Budget for a Prototype				
Item	**Priced per…**	**Quantity**	**Cost/Unit**	**Total**
2x4x3/16 in.hot rolled steel tubing	foot	38.5	$6.58	$253.33
2x2x3/16 in. hot rolled steel tubing	foot	47.5	$4.16	$197.60
3/16 in. mild steel A36 hot rolled plate	square foot	126	$10.20	$1,285.20
44 in. retract hydraulic cylinder		1	$220.00	$220.00
28 inch retract hydraulic cylinder		1	$169.00	$169.00
tires		4	$63.43	$253.72
miscellaneous parts (hose, pins, pilots, etc)		X	$1,000.00	$1,000.00
labor	hour	24	$21.00	$504.00
			Total	$3,882.85