FINAL
TECHNICAL
REPORT

US Department of Energy

Energy-Related Inventions Program
Invention 637
Grant Number 01-95EE15637

Stalk and Root Embedding Apparatus
(Pegasus Plow)

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Executive Summary

The Pegasus plow progressed from the development stage to the product support stage during the grant period. We gained the capability to plow under whole stalks as a qualified Arizona "plowdown" much sooner than we expected. This increases the savings in time, energy and cost to the farmers. It also makes cleaner seedbeds, which farmers prefer.

The USDA - Agriculture Research Service (ARS) is now in the second year of a three year study comparing the Pegasus to conventional tillage. So far, the scientists have detected no downside with the Pegasus and have documented the following benefits:

- Energy savings of 65.0 kilowatt hours per hectare over conventional tillage (Carter et al, 1996). This is when the Pegasus plow is used to bury whole stalks, and represents a 70% savings over conventional tillage (92.5 kilowatt hours per hectare).

- Four to seven fewer passes of tillage, depending on the particular situation. This represents a substantial time savings to farmers.

- So far, no differences in cotton yields. Recent cotton boll counts in one study indicate a higher yield potential with the Pegasus.

- No disease problems.

- Significantly higher levels of organic matter in the soil. A hypothesis of the study is that whole stalk burial may reduce plant disease problems. This hypothesis has not yet been proven.

- Significantly higher levels of nitrate nitrogen. Total nitrogen and ammonia nitrogen trended higher but were not significantly different. This shows that whole stalk burial does not adversely affect the nitrogen cycle in the soil and may actually improve it.

The market introduction has been very difficult, however we have made substantial progress during the grant period. We are working against a fifty year history of failed inventions and schemes to more efficiently dispose of cotton stalks. We have to prove that the Pegasus plow is the solution the marketplace has been looking for and not something that will end up parked in the fence rows next to the other failed machines.

We only made two sales, but rentals were in high demand. With only one exception, farmers have experienced very good results with the Pegasus in this introductory year. We expect this introductory effort to result in enough sales in 1997 to firmly establish the Pegasus plow in the marketplace.

We are about to begin a dealer relationship in the San Joaquin Valley of California, which we expect to be our single largest market area. This dealer will buy one new Pegasus plow for demonstrations and rentals.

The most challenging period is now behind us and we are confident that the Pegasus plow will be very successful in the marketplace. We would not have been able to reach this point without the technical and financial assistance of the Energy-Related Inventions Program.
Substantive Report

Product Development is Essentially Complete:

The invention has progressed from an engineering prototype to a commercial product.

This is no small accomplishment. USDA-ARS Agricultural Engineer Lyle Carter points out that since the end of World War II, several machines have been invented for the purpose of getting rid of cotton stalks. He made several attempts himself. None of these machines gained wide acceptance in the marketplace because they either did not do a very good job of getting rid of the stalks or they were not maintainable.

The Pegasus plow has proven its functionality and durability over several thousand acres of use. Specific durability improvements are detailed in the Technical Progress Reports (TPR's). We have not taken any chances with low-quality components or materials, therefore the Pegasus is a little expensive to make. We would much rather explain high cost than apologize for low quality. It would not be wise to risk the reputation of this invention by marketing anything less than a top quality machine. Many machines have failed in the marketplace because they were not durable.

We have examined the machine for any potential safety and product liability problems. The machine complies with all current safety standards as well as a proposed standard for warning lights. Both the safety engineer and insurance company are comfortable with the Pegasus.

Our biggest product development breakthrough came in late January 1997 when the Arizona Department of Agriculture agreed to accept whole stalk burial with the Pegasus as a qualifying "plowdown". We can thank a number of farmers for this; they got behind it and pushed the change through. This change came very late in the last season; but it increases the savings in energy, cost and time by eliminating the stalk shredding operation. Farmers also prefer whole stalk burial because it makes cleaner seedbeds.

The modifications required for whole stalk burial are detailed in the TPR's. As of this writing, three of the rental machines have been updated for whole stalk burial. One rental machine remains to be updated along with the four new machines still in our inventory. The two production prototypes have been sold. Tom Glover (the owner of the four-row machine) will purchase an update kit. Pima Gro has elected not to update their machine because they have no means of applying sewage sludge in whole stalks. We have most of the parts for the whole stalk updates in stock and will have all of them completed by the end of August 1997.

Guidance systems are essential for operation in whole stalks. We will make some specialized parts relating to the Acura Traks. An "armor kit" will protect the wires and hoses from the cotton stalks. We will develop a specialized wand sensor better suited for whole stalks. I had considered making special disk stabilizers for the Pegasus (cheaper, lighter and more compact), but will put that on hold for now and continue to use off-the-shelf Sunco stabilizers.

On the production side, we have developed a good set of working blueprints, punching dies, CNC plasma cutting programming, and welding jigs. We still need to work on improving parts procurement. We need to get better control for our parts sources by either bringing it inside Bonita Steel Builders or finding more reliable suppliers than we have had. As we buy in larger quantities we will be able to get better prices.
USDA-ARS research shows several benefits with the Pegasus. So far, there is no downside.

The benefits are:

- **Energy savings.** The Pegasus saves 70% of the energy of conventional tillage (Carter et al, 1996. A copy of this paper was enclosed with the TPR dated March 5, 1996).

- **Cost savings.** We are knocking out four to seven operations. Cost analysis with growers in Arizona show $40 to $50 per acre savings over conventional tillage in a cotton-to-cotton rotation. Savings vary from farm to farm and are easily computed on the enclosed worksheet titled Plow Under Whole Stalks! Tillage Cost Comparison Worksheet.

- **Time savings.** By eliminating four to seven passes of tillage, the Pegasus allows for much faster field turnarounds. An analysis with one Arizona farmer showed a savings of 900 labor hours with his 650 acres of cotton. This allows for more timely plantings of rotational crops such as wheat. Wheat yield potentials are greatest when the crop is planted in an optimum period of time. With conventional tillage timely planting is not always possible.

- **Soil improvements.** Irrigated desert soils are notoriously low in organic matter. Early data from the USDA-ARS study indicate that whole stalk burial slows the rate of decomposition and increases the level of organic matter in the soil. One hypothesis of the study (which has not been proven yet) is that the higher level or organic matter will support higher populations of beneficial soil micro-organisms and reduce plant disease problems. The nitrogen data so far are very encouraging, with significantly higher levels of nitrate nitrogen and trends for higher levels of ammonia and total nitrogen. This shows that the Pegasus does not adversely affect the nitrogen cycle and may in fact be improving it. Lyle Carter has asked me not to go public with the data until we are further along with the study, however I can tell you about the general progress.

- **Potential for higher cotton yields.** In an ongoing USDA study comparing the Pegasus to another tillage system, recent cotton boll counts were higher in the Pegasus plots. This may be a result of improved plant nutrition and may translate into higher yields.

The study is in the second of three years. Three years is as long as anyone in the San Joaquin Valley grows cotton in the same field before rotating to another crop. If we don't see anything adverse in this study it is probably not going to happen. USDA can't officially endorse any products, but they have adopted the Pegasus as their principle cotton tillage system at the Shafter Research Station. They also plan to use it at another research station. That says a lot.

The other benefits of the Pegasus are its low maintenance requirements and high reliability. These essential qualities are outside the scope of the USDA research but have been proven over thousands of acres of use with farmers.

Another possible benefit of the Pegasus is lower dust emissions. The Pegasus was invented in a University of Arizona research project in which we documented the high dust emissions from stalk shredding. The Pegasus eliminates shredding and several other passes. U of A Agricultural Engineer Wayne Coates now has a grant proposal pending in which he proposes document these and other benefits. Pegasus Machinery Company will cooperate with Dr. Coates on this study if it is funded.
Development Efforts are Continuing in Australia:

The Australians are still seeking a better means of cotton stalks disposal and a renewed effort is underway with the Pegasus. The University of Southern Queensland is field testing the prototype which I sold to Ellis Equipment. Ellis Equipment is cooperating in this effort.

Ellis Equipment has changed management since I exported the machine. Brian Sippel, their product development man who came to Arizona in 1994, has left the company. Brian and I still visit by phone occasionally. He advises that the current managers have no intention of doing business with me and simply want to pirate the invention with no consideration to Pegasus Machinery Company. My communications with the general manager at Ellis Equipment are consistent with what Brian tells me. All they want is a one-way flow of information in their direction.

This company is not a charity and I can't get excited about expending any effort to help Ellis do a knock-off. I will sell them design information and products (I have offered). But I will not give it away for free.

Australia only has about 700,000 acres of cotton, hence this is not a big market anyway.

We may get a cross-fertilization of ideas from the Australian development effort. I'll eventually find out what the Aussies did and how it works, this may lead to improvements to the US version of the machine.

I am still hoping that we can get in through the back door with Auscott Limited. This is the Australian subsidiary of the J.G. Boswell Company in California. We hope to get a Pegasus running this fall on one of the Boswell farms. Boswell routinely ships their used equipment to Auscott to take advantage of lower tariffs. The Auscott fleet manager visits California once a year to plan this transfer.

We are off to a modest but solid start in the marketplace.

The Big Challenge:

Pioneering the market for the Pegasus has proven to be very difficult. Our biggest challenge is to get past fifty year's history of failed stalk disposal schemes and contraptions. Virtually all of these previous inventions are now parked in fence rows as monuments to failed attempts at one-pass plowdown. We have to prove (in spades) that the Pegasus plow will not end up parked next to the other machines in the fence row. We have made a lot of headway.

We are one year behind our initial sales objective, but have progressed further than planned with product development.

Last year we thought we would sell the two production prototypes and eight new (1996) plows. We only sold the two prototypes and rented four of the new plows. We expect to sell all of the 1996 plows this year.

At this time last year, we had no idea that we would be plowing under whole stalks by the end of the tillage season. Originally, the plan was to survive with a product that plows under shredded stubble until we could get the plowdown regulations changed. In terms of what the Pegasus does, we are at least a year ahead in product development.
Current Rental and Sales Situation:

The only two sales in our first season were in Pima County. I was the County Extension Agent there for eleven years, and that's where I did most of the prototype development. Farmers there are more used to seeing the "Thackerator". The first year's results with these two machines are very positive. Wheat yields behind the Pegasus plows were excellent and all of the cotton is looking super. The good news is getting around, and we expect to make more sales in Marana this fall. One of these sales will probably be one of the rental machines. These sales will be through Burris-White Machinery Company, the local Deere dealer.

Burris-White Machinery does a lot of business in Sonora, Mexico. They had a Mexico order for a Pegasus last summer, but we could not get a machine built in time (the tillage season there season runs about two months earlier than in Arizona). There is a high probability we will make the sale this year.

The rental program in Maricopa County encompassed thousands of acres. Other than one fiasco relating to mistakes in seedbed preparation the overall results are good. These rental machines will be discounted according to how much rental revenue each one has generated. We expect to sell two or three of the rental machines to farmers who used them. Several more farmers in the area plan to try the Pegasus this fall. We will be selling through Arizona Machinery Company, the Deere dealer in the area.

Maricopa County is a tough market area in terms of what the farmers require in cotton tillage. Most farmers there use a "dry plant" technique which demands excellent residue burial. The opinion of the Deere salesmen in the area is that if the Pegasus is accepted there it will be readily accepted almost everywhere else.

The rental program was too much of a good deal for farmers. At $10 per acre plus wear parts it was very cheap for what the Pegasus does. There is no long-term financial commitment, hence some farmers would prefer to rent indefinitely. If we have another rental program we will raise the price.

We are about to begin a dealer relationship with West Kern Machinery, the John Deere dealer for Kern County, CA (three store locations in the southern end of the San Joaquin Valley (SJV)). The Shafter Research Station is within their market area, and our research work with Lyle Carter gives us instant credibility. The dealer will cement this relationship with Pegasus by purchasing one new six-row plow by September 15, 1997. This is before the tillage season begins and they will begin the marketing effort as harvest gets underway. They will demonstrate it to the local farmers and put it out on rental with a custom operator (who tills land for farmers on a per acre fee basis). I will spend about a week with the dealer personnel to get this started. This will give us great exposure in the SJV and lay the ground work for more business later on.

Dealer Contracts:

We have not yet drafted any contracts with dealers. A key provision we will want in a dealer contract is a requirement to purchase a minimum number of plows each year to keep the contract in effect (one plow per store location per year, and kept on prominent display). It is still too early in the market introduction to get any dealers to agree to that. We don't want to tie ourselves to any one dealer in a market area without setting some minimums on sales.
Publicity Efforts:

We can't afford much in the way of paid advertising. We rely heavily on the enclosed brochure and cost comparison worksheet. We distribute them to farmers in person, via direct mail and through dealers.

We developed a 17-minute product demonstration video. It is not very polished, but farmers get excited when they see it. We have distributed about 100 copies to farmers and dealers. A more professional video will follow when we can afford it.

We will sell one four-row Pegasus to USDA-ARS at our cost (money is tight with USDA). This is an investment in marketing. The plow will be displayed and demonstrated in USDA's outreach and technology transfer efforts. This gives us a great deal of credibility with farmers and dealers.

The USDA-ARS study has proven to be one of the best publicity moves we have made. The research results are much more credible than any type of paid advertising or promotions.

Farm magazines have picked up on this invention. Farmers and dealers from Texas to North Carolina have called us about a story in the Progressive Farmer. More articles will follow in California-Arizona Cotton, Cotton Farming, and Arizona Farmer. We will begin taking out advertisements later on when we can afford it.

The publicity has generated a great deal of interest in southern Texas. We are now planning field demonstrations with a Case IH dealer in the Houston area. These demonstrations will be in early September, well ahead of the tillage season for Arizona and California. Farmers as far away as North Carolina are interested, but it will be a while before we can get to them.

Product Support:

Up to this point, I have handled all of the product support myself. This includes deliveries, setup, user training and supplying parts to the dealers. Farmers have not had a single product failure or warranty claim. Ground engaging-parts are generally not warranted in this business and farmers expect to replace them as they wear out or break. Arizona Machinery Company and Burris-White Machinery sold these consumables to farmers through their parts departments. Dealer personnel have monitored the parts requirements to verify the durability of the Pegasus and they are highly impressed.

I did find one area where bolts sometimes break and have upgraded from grade 5 U-bolts to grade 8 cap screws in those locations.

Surviving the Market Introduction:

I have never doubted that this technology will be successful in the marketplace. However, I have had some doubts about whether Pegasus Machinery Company would have the staying power to survive this difficult market pioneering stage. Selling Acura Trak guidance systems has been a good sideline business and has helped keep the company afloat. I have sold fifteen Acura Traks.

This fall we expect to sell all eight Pegasus plows in our inventory. This will put us in a position to plan for growth.
The Plan for the Rest of 1997:

This is the year to fine-tune the Pegasus and firmly establish our credibility in the market. We will accomplish this before considering any more outside financing.

We had to make a full-scale production run in order to get the marketing effort started. However, we got stuck with a large carry-over of inventory of eight six-row machines (four rental and four unused). Because of this cash is very tight. We will not build any more plows until we sell all of the ones we have (the single exception is a four-row for USDA-ARS).

All of the plows will be updated for whole stalk burial. We will not raise prices until we get rid of the current inventory.

I will work very hard to sell out the inventory as soon as possible. Farmers have a convenience store mentality about equipment. They wait until the last minute before committing to buy, comfortable in the knowledge that the machine will be in stock at the store. There are a few exceptional items which they know they must order in advance. I want the Pegasus to be in the exceptional category. When we accomplish that we can get dealers to order well in advance.

Sales efforts will focus mainly on Arizona where we made the greatest efforts last season. Efforts in California and Texas will be mostly demonstration work to lay groundwork for 1998.

If we have a rental program the price will be higher. I will have a strong preference to rent to a custom operator who will go around plowing fields for a per acre fee. This will cut down on the number of moves and set-ups I'll have to do. Rentals generate some income, but you end up giving most of it away when you sell the plow. It's also a big hassle and a huge time sink.

A better option than renting is to sell a plow to someone in the area and then line him up to do custom work for farmers who want to try the Pegasus. Pima Gro will be doing custom work (they call it "dry plowing" when it does not involve sludge application) with their Pegasus for $25 per acre in shredded stubble. The plow costs less than $9 per acre to run and covers seven acres per hour. That's a gross profit to Pima Gro of over $112 per hour! After farmers try this, most will calculate that it will be cheaper to acquire their own Pegasus.

One positive development is that we have an "El Nino" weather pattern this year. In the Arizona and California that means we are in for a wet winter. Farmers will have a lot of trouble meeting the plowdown deadlines. The Pegasus will work in wetter soil conditions than most tillage implements. This should increase the demand.

Product Improvements and Support:

The various product improvements have been detailed in the Technical Progress Reports and all will be completed before the season starts.

With the excellent track record of the plows, the product support effort will consist mostly of keeping dealers supplied with consumable parts. I can continue to do that myself for one more season. We may begin depoting parts at Bonita Steel Builders; this will ensure that parts get shipped to dealers even when I am out of town.

Administrative Issues:

This company will continue as a one-man show for about one more year. The number of plows is not so great that I can't handle it. Splitting my time between Arizona and California will be a little
problematic. However, the California effort will be to continue the work with USDA and to start a demonstration program with one plow and one dealer. The California effort should not demand a lot of time this year. I will spend a week doing demonstrations in Texas before the tillage season begins in Arizona or California.

The bookkeeping system will also be upgraded. The accounting software we are now using is very comprehensive, however I am only using the general ledger and checkbook modules of it. To start up some of the modules in inventory, payroll, accounts receivable and accounts payable you have to clean the slate and start over from January 1. Other improvements will be separate sales accounts for plow whole goods, plow parts, Acura Traks, and service work. This task will keep me in a green eye shades mode for a few days.

**Plans for 1998 and Beyond:**

We will focus on selling as many plows as possible as fast as possible.

We only have fourteen years left on the patent, so we have to get our licks in. The faster we ramp up sales, the sooner we may have the possibility of selling the company and technology to a "main line" company. Deere, Case, Caterpillar and AGCO have all been acquiring shortline companies. Patent protection is important, but the key thing they look for is a demonstrated market for the product. Deere and Cat salesmen both say this can happen once you have sold about thirty machines. The company will visit each of the customers and decide whether this is a product they want to have in their line.

Market pioneering new regions will continue to be a big effort.

The dealers in Arizona should be in a routine mode by the end of 1997, with their personnel handling the sales, deliveries, setups and customer education.

We will begin exhibiting the Pegasus at farm equipment shows. I have applied for an outdoor space at the 1998 California Farm Equipment Show & International Exposition in Tulare, CA. This is the biggest farm show in the West and will be held February 10-12. We plan to share the space with Sunco Marketing (makers of the Acura Trak) to keep costs down.

By 1998, someone will have to be spending a significant amount of time out of Arizona on the market pioneering efforts. I have considered trying to use independent manufacturers' reps but am not sold on the idea. Independent reps can do well with run-of-the-mill products, but I doubt they can be expected to pioneer the market for something as radically different as the Pegasus. One problem is that the Pegasus will demand a significant investment of time and effort before sales take off. The Pegasus can get step-chielded while the rep pursues whatever is making money at the moment. The other problem is that it requires a great depth of knowledge in tillage and cotton agronomy to sell this product; this is more than we can reasonably expect from someone who is selling a lot of other stuff.

A problem is that I can't continue doing everything myself beyond one more year.

Hiring and training our own sales reps does not appear to be feasible in the near future. A fundamental problem is that the Pegasus is a very seasonal product, so what do we do with the reps during the other nine months of the year? One idea I have is maybe we can find some Minnesota or Canadian farmers who want to make money in the Cotton Belt while their own farms are frozen solid. Northern farmers don't know much about cotton, but neither do the independent reps. This option would require a strong training effort.
Another idea is to hire someone to take care of business in Arizona to allow me to pioneer markets elsewhere. The person could sell Acura Traks during most of the year. My idea is to set up a base salary and commission arrangement so the person will be highly motivated to pursue the Acura Trak business when we’re not selling plows. An attractive feature of this is that it could make it easier for me to get away for a weekend or vacation. Another consideration is that I will not be able to develop the narrow row Pegasus or develop other products without some help.

Our parts business could be handled by depoting the parts with Bonita Steel Builders; this will take some workload off of me.

**Ideas for Growing the Company:**

One idea is to grow the company on its earnings only. This is the most conservative approach because the cash available will limit growth.

Bank financing for the production runs becomes a possibility only when we can get dealers to order plows in advance.

Another idea is to go for another round of stock sales. Before doing this, I want to have all of our present inventory sold and have no debt on the balance sheet.

The dream scenario is that the product will be in hot demand. Then we can require advance orders and deposits from dealers before we build the plows. This is not unprecedented.

If demand for the plows greatly exceeds our ability to build plows, we may be better off selling out to a firm with the resources to meet the demand.

**Ideas for Reducing Production Cost and Increasing Capacity:**

As we go up in volume, we will reduce per unit costs by buying parts in larger quantities and bringing more component production in-house. We will pursue efficiencies such as painting by tank dipping to cut labor costs.

Total capacity at Bonita Steel Builders will be about 100 plows per year if they build nothing else. The bottlenecks are in painting and final assembly. It would not require a huge investment to double their plow capacity by adding dedicated painting and final assembly facilities.

If we get into the range of 50-100 plows per year, Pegasus and Bonita will become very dependent on one another. At some point a merger may be appropriate. This would facilitate the drive to reduce costs because we would all be looking at the same bottom line. Bonita has asked to be included in any future rounds of stock sales.

**Plans for Packaging and Shipping the Plows:**

One thing that puts us at a cost disadvantage is that we now assemble the plows at Bonita Steel Builders at a cost of $37.50 per hour. We must do this at first because we can't rely on dealers to assemble plows during the market introduction. Most farm equipment is shipped "knocked down" and the dealers do the final assembly. When setting retail prices dealers start with the invoice cost of the implement, add their markup, add the freight cost, and add an assembly cost at a $40 per hour shop rate. With a Pegasus, dealers are marking up our final assembly cost (which we mark up and build into the invoice cost) but are not adding a final assembly cost. This makes our list price look a lot higher than it would otherwise be, however the ultimate price quoted to the customer is a only little higher.
The alternative of shipping knocked down equipment means that we would have to palletize or crate the parts and ship them along with the tool frames. However, if you don't fully utilize the truck's load capacity the freight costs are steep. Making efficient use of the truck load capacity requires stacking the tool frames, pallets and crates in some kind of specialized rack or fixture on the truck bed. This means that we would have to own some trucks, something I do not aspire to do. Other problems are that loose parts bang around in transit and you can't always rely on dealers to assemble the product correctly. Deere quit shipping planters knocked down because of persistent problems with dealers mis-assembling them.

Our plan at the moment is to ship the plows assembled and standing on their front ends. We will bolt two pieces of rectangle tubing to the front of the plow to act as shipping skids and forklift pockets. This will allow six assembled six-row plows (or eight four-rows) to be carried on a 60-foot truck bed (with allowable front and rear overhangs). We will try this on the one six-row plow we will sell to a dealer in California this September.

Later on we will attempt to reduce our assembly costs. This is one of the bottlenecks at Bonita and must be fixed as volume increases. A final assembly area with an overhead gantry crane could greatly reduce the labor hours.

**Future Possibilities for Product Development:**

To gain the maximum market penetration across the Cotton Belt we will have to market a narrow row model. This will not be a simple matter of using our existing plow units. I have several ideas on how to design a narrow row model, but this will have to wait until we have the cash flow and personnel to support a renewed product development effort. We'll have to do or die with the current product.

Another development possibility is to look into the use of an electro-osmotic field on the Pegasus to reduce the draft forces. Published research shows that charging a tillage tool with about 30 volts of electricity significantly reduces the draft energy requirement. The effect increases with soil moisture. This has been known for over seventy years and it has applications in rock drilling. I don't know why it is not used with farm equipment and might find out that there is a good one. However, this could result in an optional gadget for the Pegasus.

One possible way to pursue these and other ideas would be through a Small Business Innovation Research (SBIR) grant. I have ideas for other products, but again these will have to wait until the Pegasus is better established in the market.
Conclusions and Recommendations

During the grant period, the invention has moved from the development stage to the product support stage (as defined by the National Institute of Standards and Technology). These conclusions and recommendations will directly address the desired outcomes in the statement of work in our ERIP contract.

Task 1: The applicant sells the thoroughly tested 1994 prototype to Ellis Equipment, Ltd., for commercialization in Australia.

Conclusion:

Developmental efforts are still under way with the University of Southern Queensland and Ellis Equipment with their prototype. Evidently the Australians see this as one of the most promising solutions to the cotton stalk disposal problem. However, it appears that Ellis Equipment is attempting to pirate the invention and intends to leave Pegasus Machinery Company out in the cold.

Recommendation:

Work to sell Pegasus plows to the J.G. Boswell Company in California. There is be a good chance that these plows will end up in Australia (Auscott), and of course Boswell will need to buy replacement plows for California. We will also attempt to find out about any progress the Australians make on their own.

Task 2: Two fully functional four-row and six-row prototypes meet all energy-saving criteria and are ready for mass production.

Conclusions:

These two machines are still in use with customers. The four-row is owned by Tom Glover in Marana, he will update it for whole stalk burial. Pima Gro owns the six-row and has elected to continue plowing under shredded stubble because they have no means of applying sewage sludge in whole stalks.

The development progressed further than I expected during the contract period. I did not think that we would be plowing under whole stalks on large acreages by now. All of the design modifications required for whole stalk burial will soon be complete.

The energy data from the USDA-ARS study shows that the Pegasus saves 70% of the energy requirement of conventional tillage (Carter et al, 1996).

Recommendation:

We will continue to work with USDA-ARS and university scientists to explore applications and benefits of the Pegasus.
Task 3: The applicant successfully communicates to farmers and dealers in the industry the benefits of the technology. A manufacturer fabricates and ships the Pegasus to various dealers, and the applicant gives field demonstrations of the invention to cotton farmers.

Conclusions:

In terms of sales volume, we are about one year behind schedule. The problem is that after fifty years of failed efforts at one-pass cotton stalk disposal most farmers did not believe the benefits of the Pegasus. We have made a lot of headway and expect sales to pick up this year.

We are in reasonably good shape with the manufacturing, however we have more work to do in cutting costs and in getting better control of our parts sources.

The rental program is essentially a series of paid demonstrations. For a demonstration, we will come out and make a few passes with the Pegasus. If the farmer wants to do the whole field, then we proceed on a rental basis. We cannot afford to give away much machine time. Demand for rentals was strong, however rentals are not really profitable and are a huge time sink.

Recommendations:

Keep up the intensive sales effort and sell all of our current inventory by the end of 1997.

Continue to pursue improvements in manufacturing process and parts procurement to cut costs. If volume increases to 50-100 plows per year we should explore the possibility of a merger with Bonita Steel Builders.

Explore other means of letting farmers try the technology without us having to directly rent the machines as we did last season. We will have dealers own and rent machines, and they will attempt to rent to custom operators who will cover large acreage with several different farmers. Demonstrations will continue in regions where we are pioneering the market.

Task 4: The Pegasus is rapidly accepted by cotton belt farmers and the Pegasus Machinery Company is expanded accordingly. The inventor projects that the technology will be ready for leasing by 1997.

Conclusions:

Our minuscule market penetration is a modest but solid beginning. We expect last year's effort to pay off in sales this year.

Leasing programs are available through commercial banks. One of our sales was a lease/purchase through Farm Credit Services.

Recommendations:

Keep up the marketing effort, as outlined in this final report. As sales ramp up, expand the company accordingly.

We should be aware that the potential for this invention could grow beyond our ability to meet demand. If this happens, we should not squander any good opportunities to sell out to a larger firm such as Caterpillar, John Deere, Case, or AGCO.
We could not have reached this point without the technical and financial assistance of the Energy-Related Inventions Program.

I have never questioned the potential of this technology. But even with DOE's help, I have questioned whether this company would have the staying power to get through the product development and market roll-out.

Without the ERIP program, the technical risks and development costs would have been too great for the company to have attracted the resources and expertise required to pull this off. The idea of plowing under whole stalks sounded very outlandish a few years ago and was not something that would have interested a larger company.

The training at the Commercialization Planning Workshop (CPW) was especially helpful. Before the CPW I had just competed an MBA in Entrepreneurship at the University of Arizona's Karl Eller Graduate School of Management. This is ranked as one of the best entrepreneurship programs in the country and I won the 1992 Business Plans Competition with a business plan for the Pegasus. In spite of this, DOE has taught me most of what I know about new product development.

Of course, the marketplace will be the final arbiter of success of the Pegasus plow. I am confident that we will do very well, and am very grateful for DOE's assistance.

Literature Citation


Equipment With an Acquisition Cost of $1,000 or More

There is only one item. It is an Apple Macintosh Performa 6300CD, serial number XA6024BP6BV, purchased February 25, 1996 at a cost of $2,621.47. I will probably have to install a pentium chip in it to be able to continue using it much longer. Replacing it may be more economical.

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