PEGASUS
MACHINERY COMPANY

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RE: October - December 1995 Technical Progress Report
Instrument No. DE-FG01-95-EE15637, ERIP Invention 637.

Dear Lisa,

I'm now back at the University of Arizona, earning a paycheck. As you will see, my nights and weekends will continue to be devoted to the business. Rather than bending metal and field testing machines, I will be generating a lot of paper over the next few months.

The last quarter was very busy and productive. I encountered and overcame some unexpected problems with the machines in very dry soil. While the product development moved along well, I am behind on some business issues and am now most concerned about that. Here is where the project now stands, according to the statement of work in our contract:

Task 1: Field Test and Sell Prototype to Ellis Equipment, Ltd.

1. Sell the 1993 prototype to Ellis Equipment, Ltd.

The Australians' experience with the machine is reported in the preceding Technical Progress Report. While the machine showed promise for Australia, both of the people I had been working with have left Ellis Equipment. The firm is in financial distress and is now under new management. I stay in touch with Brian Sippel, the former Ellis product development man. Brian has a dim view of the new management ("big city blokes who don't understand farming"), and advised me that they are not enthusiastic about working on a new product. I have not detected any current interest directly from Ellis, although I have not completely given up hope.

Most likely, Ellis is a dead end for the Pegasus. There is, however, another possibility which I will pursue. One of the larger cotton producers in Australia is Auscott Ltd., a subsidiary of the J.G. Boswell Company. Boswell is the largest cotton producer in the US, in California's San Joaquin Valley (SJV). I hope to sell machines to Boswell, since the one million acres of cotton in the SJV will be the single largest market for the Pegasus. Auscott's fleet manager has told me that they often import used equipment

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from their parent company (Australian import tariffs are lower on used equipment). That would be an indirect way to get production models of the Pegasus into Australia.

Another possible avenue is a contact Dr. Coates has with one of his counterparts in New South Wales. He is Dr. Neville Gould at NSW Agriculture. I plan to mail him a copy of the same videotape that will follow this report.

2. Complete field test work on the 1994 prototype...

As part of the Cooperative Research and Development Agreement between the USDA and Pegasus, the USDA paid to have the 1994 prototype updated with the latest design changes. The purpose of this was to use the machine in research work at the USDA-ARS Cotton Research Station in Shafter, CA. Because this updating made the 1994 prototype functionally the same as the two full-scale machines, it proved to be very useful in solving some unexpected problems working in hard, dry soils.

The fall of 1995 was extraordinarily warm and dry for both Arizona and Southern California. Usually, storms in November and December leave some moisture in the soil. In 1995, the lack of rain together with record and near-record high temperatures combined to make the soil extraordinarily hard and dry. Cotton plants continued to pull moisture from the soil until they were shredded. Many farmers in Arizona parked conventional moldboard plows because they either would not penetrate the soil, or they would break frequently, or they would produce huge clods which would mandate many more tillage trips.

Every tillage implement has limitations. While the Pegasus will run in wetter conditions than many other implements (such as disk harrows), it gets into trouble when the soil is very hard and dry (as any moldboard plow does).

I spent the first two weeks of November working on the dry soil problems, using the 1994 prototype in Marana (near Tucson). I spent the third week of November working with Lyle Carter and his associates at the USDA-ARS Cotton Research Station, and we spent most of that time working on the dry soil problems.

The unexpected problems with hard soil, and what we did about them:

1. *Huge clods would come up off the plow shares and stack in front of the disk bedders.* Soil generally shears at a 45-degree angle upward and outward from a plowshare, in dry soil this produces very large clods ("monoliths", according to Lyle Carter). These monoliths would not flow well between the opposing row units, and would stack up in front of the disk bedders which normally split the large flow of soil that moves between the row units.

   We improved the situation with a change shown in Figures 1 and 2. Figure 1 shows the clearing disks in front of a pair of plow units. These single 18-inch disks are very effective in keeping debris from stacking on the moldboards. Adding the second 20-inch disk blades (Figure 2) was a simple matter of using longer gang bolts, adding cast plates to sandwich the disk blades, and the disk blades themselves. The three ball bearings inside the bearing sleeve are designed to carry two disk blades, so the additional bearing load is not a problem.

   The additional 20-inch disk blades in front of the plow shares reduce the size of the monoliths coming up off the plowshares (Figure 2). They cut the very large clods in half. In some conditions, the two blades bend the surface soil as it flows between them, thus pulverizing some of the soil.

This change only provided a degree of relief. We had dry plots at Shafter, along with wet plots which had received a light irrigation to simulate a rainy year. The dry plots were hard as a roadbed, and we still could not make the machine work satisfactorily. Lyle Carter points out that farmers in that area have long ago given up on trying to stick a plow or ripper in that type of soil when it is that dry. It is not uncommon for farmers there to irrigate to enable tillage work.

2. *The "stuffer" disks would stall after hitting large, hard clods; this would cause the machine to plug up.* We solved this problem by adding driving lugs to the outside of the stuffer disk blades (Figure 3). At first we tried using twelve lugs, the same as the number of stuffer teeth on the inside of the blades. Twelve lugs were too much, and tended to make the disk climb out of the soil and lift the whole machine. Six lugs proved to be very effective.

   Again, this only provided a degree of relief. Occasionally, we hit clods which were stout enough to overpower the driving lugs and stall the stuffer. One farmer who used the six-row machine near Casa Grande, AZ told of hitting such a clod. He removed it, and tried to see if he could break it by pounding on it with a 15-inch crescent wrench. He couldn't break it. However, he only had to clear the machine twice in a 40-acre field (about six hours work). This is a condition we only expect to have in one or two years out of ten.

   Lyle Carter came up with the term "stuffer disk", which is more descriptive of how they push the stalks under.

3. *Difficulty getting the Pegasus to penetrate the soil.* The solution to this was simple. The root knives (Figure 4) were oriented such that they had a lifting action in the soil. The solution was to drill another hole in the row unit to reposition one carriage bolt and give the knife a downward angle, to help pull the implement down.

   Even then, the Pegasus will "chatter" in very hard soil. This is not unusual for a plow when it is tearing large clods out of the ground.

While these changes provided some relief, they did not solve the problems enough to enable us to work the dry plots at Shafter. It performed beautifully in the wet plots.

In this problem-solving process, Lyle Carter and his associates taught me a lot about field testing and evaluation of tillage equipment. We would stop the machine in the middle of the field and dig the soil out from around it, while examining tool marks on dirt clods to gain a better understanding of how it moves the soil. It sure helped to have some USDA-ARS engineers working on the machine.

I had originally planned to leave the 1994 prototype at the Shafter Research Station, mainly to save myself the trouble of hauling it back for our 1996 test (this is a three-year research commitment). However, after making these changes, the next thing I wanted to do was to stick it into some Arizona soil and see it would work satisfactorily. So I hauled it back to Marana and found that the changes were a vast improvement.

Having solved the problems with the 1994 two-row prototype, I then went to work incorporating these changes to the new 4-row and 6-row machines which had not yet been in the field. *By this time it was the first of December*. While this was two weeks behind schedule for starting the on-farm demonstrations, it is always a mistake to show a machine to a farmer before you have it working well.

Verify functionality of plow moldboards.

The flow characteristics of the new design moldboards proved to be very good for most field conditions (Figures 5). Sometimes they would carry soil bodies in the deep bend, however these generally stayed above and to the rear of the area of soil pressure and did not appear to cause significant additional drag. Dr. Coates advises that any moldboard is a design compromise, hence it is impossible to design one moldboard which is optimal in all conditions. Most of the R&D work on this was done in Marana, and it turns out that it works best there and in areas with similar soil types.

We did run into some manufacturability problems with the moldboards. The abrasion-resistant plate steel required here does not lend itself to deep brakes (bends). We knew this, and were absolutely sure that 3/8" AR400 would break before it would bend that much. Therefore, we tried 1/4" AR400, and even that cracked (Figure 6). An additional problem was that the sharp corners at the front and rear ends could not be bent in the press brake without cutting a slot in the metal and then re-welding it after bending the plate. This added to the cost of the moldboards.

Another problem was that the 1/4" moldboards just didn't last very long in the field. They also fit poorly behind the 3/8" thick plowshares.

Bill Matthews at Bonita Steel suggested making the moldboards in two pieces and with thicker plates. We tried it with 3/8" AR400 (Figures 5 and 8), and it was a big improvement on several counts:

- They are cheaper to make. Even though there is 50% more steel in them, the labor cost is far less.
- They last longer because there is more steel in them. The major wear area is the leading edge of the upper piece, which appears to wear 3-4 times faster than the lower section. It would be easy for the farmer to remove five bolts to re-hardface or replace the upper piece.
- Fit-up to the share is much better.

We can consider this task to be successfully completed. In the future, I will test a weld-on chromium cutting edge on the high wear area as an alternative to hardfacing. That's a minor refinement which can wait until later on.

Test trash coulter and clearing disk designs.

Last year's test work showed that a concave clearing disk is superior to a flat trash coulter. The only remaining issue was how to mount the disk so that it would not cause problems with plant material or soil flowing into the implement.

The mounting arrangement is shown in Figure 9. This utilizes many off-the-shelf parts, including the 18-inch blade, the cylindrical bearing sleeve, the disc bearings and retaining rings inside the sleeve, the cast iron "rear plate" and the cast "spool". The gang bolt is a piece of 1-1/8" hard steel square stock with a small plate welded to one end and threads on the other.

At first, all three prototypes were updated with a single 20-inch clearing disk blade. A problem was that the 20-inch blade required that the bearing sleeve be one inch closer to the ground than with an 18-inch blade. In many conditions, the bearing sleeve was dragging on the top of the beds. This obviously would not last in the field, so I had Bonita Steel Builders raise the bearing sleeves up one inch and change the lateral positioning slightly to accommodate an 18-inch blade. The vertical 3x3" tubes had to be shortened and re-drilled to do this. This caused a mis-alignment between the 3x3" tubes and the mounting ears of the bearing sleeves (Figures 9 & 10). That is a cosmetic problem that should be addressed before going into production.

The double disk arrangement is shown in Figure 10. This is for the hard soil conditions, as discussed before. I plan to sell the machines with the double disks. However, in wet conditions the double disks will probably cause soil flow problems. Therefore, I will include with the machines spacer bushings to enable the farmer to remove the 20-inch disk and install a spacer in place of the additional blade and cast plates. This will eliminate the need to replace the gang bolt with the shorter bolt used in the single disk configuration.

I tried two different kinds of disk blades. The blades shown in Figures 9 and 10 are plain spherical disk blades, available at virtually every farm equipment dealer parts department. They worked very well, and they're cheap. On the four-row machine, I tried Ingersoll Duraflute blades of the same size and spherical configuration. They have a finely fluted edge and are about twice the money as plain blades. Most dealers don't carry them. They did not appear to perform any better than plain blades, so I will go with the plain blades.

Field performance of the clearing disks was very good. Now the implement will tolerate a substantial volume of cotton roots passing around the wrong side of the plow without plugging. Much of this improvement is due to having a more open area behind the clearing disk than the earlier design plow had. This gives debris more area to fall out, either into the soil flow of the plow or to where the stuffer disk will grab them.

We demonstrated the six-row machine in two fields that had been re-planted, and there were two distinct lines of cotton plants on each bed, often six inches apart. There was no way to avoid passing roots around the wrong side of the plow. The machine only plugged six or eight times in 130 acres. This would have been an impossible situation for the earlier design clearing disk and plow. While the results in the double planted fields were less complete residue burial than usual, it proved to be quite satisfactory as a wheat seedbed.

The clearing disks performed well when plowing under whole stalks in the research work with Lyle Carter. The bearing and mounting assemblies are now completely out of the flow of plant material.

The only tasks remaining here are to clean up the fit of the 3x3" tube to the bearing sleeve ears, and to relocate the top plate bolt holes to accommodate a change to be presented later in this report.

Disk bedder attachment:

The design changes here proved to be successful and trouble-free. The bearing sleeves and associated parts are the same as used in the clearing disks up front, except that the disk blades are 22-inch. The key to making the two tightly staggered disks work together is to keep debris from getting caught in the pinch point between the two disks. This will stop the disks from turning, which will quickly plug the machine with soil.

A debris shield positioned between the advancing edges of the two disks will keep the disks turning free (Figures 11 & 12). Bonita Steel originally located this shield too far to the rear to be effective, and I didn't catch that in the prototype construction. I later fabricated some L-shaped plates to move the shields forward (Figure 12). Another improvement was to attach the shield with carriage bolts and slotted holes to make the shield adjustable relative to the disk blades. The disk bedders have been completely trouble-free since this change. This debris shield is only required for the disks bedders which split the large flow of soil between two plow units. The other disk bedders only re-run existing furrows, hence do not encounter the high flows of soil (Figure 13).

Some minor changes should be made before going into production. We had punched extra mounting holes in the flag plates of the disk hub assemblies to allow testing of different mounting arrangements (Figure 14). Those extra holes can be deleted.

Another minor change will address how soil get pressed against the back side of the leading disk blade. This soil compression happens in the pinch point, and this very tight band of soil sticks to the back side of the front blade and wears a notch in the debris shield. A small scraper (about 2" wide) can easily be added to the back side of the debris shield. It will be attached and will be slidably adjustable with one carriage bolt. This will keep the soil peeled from the back side of the front blade and will protect the debris shield from wear.

In expectation of normal fall weather, we made scrapers for the disk bedders (Figures 15 - 17). We did get 1/2' of rain in early November, and I ran right out to test them in the little bit of wet soil we had on the surface (it was hard and dry underneath). They worked fine, and they are only required on the disc bedders which split the large flow of soil coming between pairs of plows. The other disc bedders (Figure 13) are essentially re-running existing furrows and do not engage enough soil to require scrapers (this was not a problem in very wet soil last year).

Alternative configurations for engaging teeth:

We determined the optimal shape of the teeth in last year's testing (Figure 18). This year, we tried making them out of mild steel and abrasion-resistant (AR) plate. AR plate is much stiffer than mild steel but is also more brittle. The AR teeth cracked slightly in the 90-degree bends. The mild steel did not crack.

In the field, extraordinarily hard clods bent a few of the teeth, even some of the AR's. The teeth are not hard to straighten with a large crescent wrench. These teeth are not subject to abrasion, and none are showing noticeable wear after 800-900 acres on both full-scale machines. We could bend AR plate on a larger radius to prevent the cracking, but I'm not convinced that we need high-dollar hard steel for this application.

In one instance, a stuffer hit a rock, the carriage bolts sheared off, and we lost a whole stuffer tooth.

The driving lugs on the outside of the stuffer disks (Figure 3) definitely need to be made of AR plate. Those things really dig in the dirt. We kept the radius of the bend large enough to avoid cracking. The outside corners have worn down slightly in 800-900 acres of use, but are nowhere near needing replacement.

The stuffer disks appear to have very long service lives (Figures 3 & 18). They show very little wear. This is not a big surprise, since they essentially work as wheels and are not pulled sideways through the soil as disk harrow or bedder blades are.

Scraper for the stuffer disk:

Right after a 1/2" rain in early November, I found that sticky soil is not the only problem. Wet cotton stalks tend to wrap around the stuffer teeth, and you have to get them off. Our first design attempt would remove the soil but not the stalks. The second design worked fine, with a gentle wiping action which pulls stalks out off the end of the stuffer teeth. This new design uses the same scraper for either left or right stuffer disks (Figure 19).

Brain Sippel told me that he had the same problem with stalks wrapping around the stuffer teeth in Australia.

I think this task is complete, but can't be totally sure until we get some really wet conditions.

3. Review the design with a safety engineer and insurance company...

We now have a product liability policy on the Pegasus with Sentry Insurance, under the Farm Equipment Manufacturer's Association (FEMA) group plan. This policy also provides coverage for the three prototype machines. The premium was $3,000. I had not budgeted for that much.

We are still in the loss control review process with Sentry. The Sentry people advise me that they don't see any problems with the machine. It has no PTO or hydraulic components, which are the usual hazards. It has warning lights, reflectors, and a Slow Moving Vehicle (SMV) emblem. All we lack are warning labels (about the stuffer disk teeth) and an operator's manual with the proper discussions about safety.

Sentry was supposed to send a loss control specialist out to see the machine and visit with me and Safety Engineer Jim Morris (they haven't yet). On the phone, they told me that we have really done our homework and identified the issues, and that they just don't see much liability exposure. That kind of makes me feel like I'm not getting my money's worth out of the insurance, but I don't know what my alternatives are.

This spring, Jim Morris and I will develop the warning label relating to the stuffer disk. I will produce the camera-ready graphics with a desktop computer to save money. I have been communicating with two decal manufacturers who routinely print warning labels to all relevant safety standards. The label will point out the hazard, tell how to avoid it, and graphically show the consequences of not heeding the warning. A label will be affixed to the rear end of each plow unit.

As a stop-gap measure, I stenciled "DISK TEETH CAN GRAB YOU, DO NOT RIDE" near each stuffer disk (Figures 20 & 21). We have not had a problem with people riding on it.

FEMA now has a tillage safety committee which is developing generic safety labels for tillage implements. These are due out any time now, and I will review these for possible use on the Pegasus.

Jim Morris and I also need to develop the safety section of the operator's manual.

One safety issue relates to convenience when using the machine. Farmers often throw SMV's away if they get in their way. We are thinking about sticking the SMV to a toolbox. In some of the demonstrations, I mounted an old 20MM ammo box on the machines to hold spare plow shares and root knives. Farmers thought it was a great convenience. Without the box, the spare parts are rolling around on the floor of the tractor cab. Farmers won't throw a toolbox away.

Task 2: Design, Build, and Field Test Two Prototypes.

1. Design and build a mount for the hub and spindle assemble of the stuffer disk.

This simple mount is shown in Figures 20 and 21. It has a 5/8" pivot bolt in the front and two 3/4" bolts in the rear in slotted holes. The only adjustment is for the height of the stuffer disk, and that is all that is needed. The piece of 2 x 2" square tube extending to the rear holds the scraper for the stuffer disk.

Because the prototypes were built without the benefits of jigs or fixtures, some dimensions varied and showed how critical the angles of the hub and spindle assemblies really are. One stuffer disk on the four-row machine consistently plugged up with stalks which collected inside the circumference of the stuffer teeth. This disk was angled outward into the incoming stalks more than the others. I replaced it with a part from the two-row machine and never had any more trouble. When setting up the jigs, we will really have to watch the angles of the bearing spindles.

Another problem related to quality control. Bonita Steel Builders left weld spatters on the seal journals of the spindles. This trashed some of the grease seals, which then let dirt into the hubs, which then wrecked some of the tapered roller bearings. This problem showed up at about the 800 acre point on two hubs of the six-row machine. I will have to make sure that the contractor cleans the "dingle berries" off the spindles before mounting the hubs.

There is one manufacturability problem that should be addressed. The 3/8" plate for this part is first flame cut in a CNC plasma cutter. The adjusting slots and front pivot hole are "burned" as the piece is cut. Then, two 90-degree bends are made in a press brake. The lower adjusting slot is too close to a bend in the metal, this makes the bend more difficult and time-consuming to make (Figure 20). The lower adjusting slot can easily be located further from the bend.

Redesign the plow units.

First, I built a full-scale plywood mock-up of the plow unit (Figure 22) and then brainstormed it with Wayne Coates. Bonita Steel Builders made their CNC plasma cutting patterns and measured press break angles right off this mock-up. The parts fit together perfectly. The fit-up and welding went smoothly, in spite of not having any jigs or fixtures.

I was concerned about wear on the long plate behind the moldboards, so we made them out of 3/8" AR400. This is the same material ripper shanks are made of and has very good abrasion resistance. While this is the part of the plow unit that runs in contact with soil, this soil has been loosened by replaceable soil engaging parts. Wayne Coates and I will inspect the polished areas for any wear problems.

All of the other plate steel is mild 1/2". Every agricultural engineer who has seen these plow units has pointed out how they are very strong, well triangulated, and over-built. Indeed, we have not bent or broken one yet.

While the machines are heavy, I am not inclined to take any steel out of the plow units. At about 5,000 pounds total weight for the four-row and 7,000 pounds for the six-row, they will make a tractor squat. However, the weight is well within the three point lift capacity of any tractor which is big enough to pull it. The center of gravity seems to be about one-third of the way back in the machine, so the moment on the three point hitches is not unmanageable. Another weight consideration is that I'm not sure the machine will be able to do everything it needs to do if it is substantially lighter.

I do want to make some minor changes before going into production. The only problem I had with the plow units was they would scoot on the toolframe if the bolts weren't kept very tight. These are 10-inch long bolts which wrap around both the 4x4" tube of the plow unit and the 4" tubes of the toolframe (Figures 23 & 24). These long bolts are a carry-over from earlier prototypes, when I was shifting the plows forward and backward to figure out the dimensions of the machine. Now it is time to go with something simpler.

I will relocate the 1/2" plates with the bolt holes to underneath the 4 x 4" tube of the plow units (Figures 23 & 24). These plates will be widened 4" to make room for the 3/4" nuts next to the 4x4" tube. This will more than double the area where the plow unit contacts the toolframe, hence should make the plows less likely to scoot. At the rear attachment point (Figure 24), I will delete the 1/2" plate on the under side of the toolframe and use two 3/4" U-bolts instead of the four hex bolts. At the front attachment point (Figure 23), the 3/4" holes in the top plate of the clearing disk mount will have to be relocated to match the new bolt holes in the plow unit. The 5/8" U-bolt which wraps around the 4x7" toolframe and bolts to the clearing disk mount will be deleted (Figure 23).

The U-bolts holding the plow units to the mast of the toolframe will essentially stay where they are, however the vertical 1/2" plate will change slightly to accommodate the 4x4" tube being 1/2" higher (Figure 23).

With no other changes, this would have the effect or raising the plows 1/2" in relation to the clearing disks and toolframe. I will not take any chances with this, and will shift the plate steel of the unit down 1/2" to maintain the original plow height.

I still have the plywood mock-up, and will use it to model the changes.

Another change relates to the front pivot bolt for the stuffer hub mounting assembly. This 5/8" bolt is held by a hex nut inside the plow unit (Figure 21). The hex nut and lock washer are hard to install in this tight spot, and are a pain to tighten. It will be a simple matter to weld the hex nut on the inside of the plow unit while the plow is being built.

Improve mounting hardware for the clearing disk.

This was resolved on the two-row machine, and is reported under Task 1. Some mounting holes will be relocated, as reported in the discussion on plow units.

Simplify the disk bedder attachment.

This was resolved on the two-row machine, and is reported under Task 1.

Design and test a stalk deflector for the plow units.

This is not specified in out contract, but is something I had to deal with. Stalks often fell into the slot before the stuffer teeth could engage them to push them down. This resulted in stalks not getting well buried in the slot. The stalk deflector is the triangular piece of AR400 plate best shown in Figure 4. The function of this piece is to funnel stalks into the stuffer teeth. At first I tried a 20-degree angle in the plate, but it proved to be too much and caused stuffer disk stalling. A 10-degree angle worked better, as shown in the photo.

2. Select a farm machinery manufacturer.

I'm a little distressed that this has not been resolved yet. If Bonita Steel Builders can stay in the ballpark on costs, I would prefer to do business with them. In early October, the vice president of Pegasus (my father-in-law, a retired colonel and former CFO of U-Haul) and I met with Bill Matthews at Bonita. We showed Bill what our target retail prices were, what the dealer margins are, and what our target margins were. Essentially, we told him that if he could build four-rows for around $11,000 and six-rows for around $16,000 that we could do business. We also explained how we expect to pay for and own the jigs and fixtures.

Several weeks later, Bill told me that he could deliver machines at the prices we had talked about. We then pulled out the information I had left with him, and found that he was looking at our selling prices to dealers. I'm afraid that manufacturing is a different ball game than the job shop business, and that Bonita just won't be in the ballpark.

I am still talking to Bigham Brothers. Sandy Kimball said that if we would make a 50% down payment before he began construction and pay the balance on delivery of the machines, he would cut his prices by about 30%. If we do this, I will have a lawyer wrap up the whole deal in boiler plate. Even then, you can imagine how I have some reservations about doing business there.

As soon as I mail this TPR and file paperwork to get current on our grant finances, I will begin shopping this around in earnest. I have a copy of the Ameritech Industrial Purchasing Guide for Southern California and Arizona, and will make good use of it. I will also contact some FEMA members in California.

One problem is shopping this around is that we don't have good engineering drawings of the machines. No manufacturer will quote a firm price without inspecting the machines or having engineering drawings. Wayne Coates advised me against spending money on drawings before building the prototypes, because design changes were inevitable and the drawings would soon be outdated. That was good advice. However, to shop this around by mail good drawings will be essential. There is an engineering shop in Tucson with an expertise and good reputation in generating drawings. We may have to bite the bullet and have some made.

This issue has been a problem when demonstrating machines with farmers. I don't know what it will cost to make, and can't quote a retail price. The dilemma is that there is only one time of year when you can demonstrate the machines, and if you don't demonstrate, nobody will want to buy, no matter what the price is. More about that later.

Make a business plan.

I made no progress on this in the last quarter. The business plan will be absolutely essential in securing inventory financing. There are two banks who specialize in farm equipment inventory financing, but before going to them we need to know what the cash flow problems are. The manufacturing issue must be solved before we can determine that.

One inventory financing idea we have is to issue some short-term bonds with some wealthy relatives to cover the period between getting the machines built and getting paid by dealers. The only thing that scares me about this is that banks know how to secure their interest in the machines in case a dealer goes belly-up, and I don't know how to do it.

Develop CNC machine tool programming and welding jigs.

Again, we will have to resolve the manufacturing issue before proceeding on this.

Acquire a truck and trailer to transport the prototypes.

Figure shows the implement carrier in the "unloaded" position (Figure 25). With a Pegasus on the platform, it takes a 4X4 truck or a tractor to push it back up onto the undercarriage. Short of owning a flatbed truck and a forklift, I don't know how else to move the machines around as much as I did. The trailer has no springs and is a stinker to pull, but at least it has good brakes.

3. Build full-scale preproduction four-row and six-row prototypes.

Bonita Steel Builders completed the machines (Figures 26 & 27) and I paid for them on November 3rd. As discussed before, I did not put them in the field until early December due to the problems with extraordinarily hard and dry soil.

In addition to the ERIP funds that I paid directly to Bonita, I had purchased many of the components with non-federal funds. Many purchases included parts for the old two-row machine along with the two new machines. I allocated the costs of parts to each machine in each transaction and posted them to my books accordingly.

According to my books, the four-row prototype cost $20,705.74 and the six-row cost $29,497.65. This comes to a total of $50,203.39, just over the $50,000 in the grant budget. There were a few unforeseen expenses, like re-doing the stuffer disk scrapers for $651.00 and re-doing the moldboards for $1,522.50. As soon as I mail this TPR I will prepare a detailed report on the expenditures.

4. Field test the prototypes for energy savings.

We collected the energy data in our field test at the USDA-ARS Cotton Research Station in Shafter, CA (Figures 28-33). The treatments in the test are:

1. Whole stalk zone burial, using:
   a. The breadboard "disk" prototype (Figure 28) of the Pegasus (the one shown in the patent).

   b. The preproduction "moldboard" prototype (Figures 29 & 30) of the Pegasus.

2. Shredded stalk zone burial, using:
   a. The breadboard "disk" prototype (Figures 30 & 31) of the Pegasus.
   b. The preproduction "moldboard" prototype (Figure 32) of the Pegasus.

3. Conventional tillage consisting of stalk shredding, disking, ripping, disking, and relisting.

As discussed before, we had planned to have both wet plots (which had been irrigated to simulate a wet year) and dry plots. The dry plots were absolutely unworkable due to the record high temperatures and a complete lack of rain.

We measured the Pegasus three point hitch draft forces and implement speeds through all of the plots. Lyle Carter is still compiling the data, and I will send it to you as soon as I get his summary. The "disk" prototype had a higher energy requirement than did the "moldboard" prototype. This difference is largely due to the ripper shank on the front of the disk prototype (the ripper is required for soil penetration in many field conditions). The energy requirement of the moldboard prototype is similar to what Wayne Coates and I measured in 1993 on the prototype that is now in Australia (these are the data in my ERIP application).

We did not have instrumentation to measure draft forces from a drawbar nor did we have a PTO torque meter. These would be required to measure energy requirements from the other implements such as the stalk shredder and disk. Lyle Carter points out that energy requirements for these implements do not vary substantially across different field conditions, and that the data Wayne Coates and I collected from such implements in our research work will be quite suitable for comparison purposes.

If we can skip the stalk shredding operation and bury whole stalks, that of course is an additional cost and energy savings. However, the objectives and potential impacts of this study extend far beyond energy conservation. One of the principle hypotheses of this study relates to how we may be able to preserve organic matter in our Western soils (which are chronically very low in organic matter). Lyle Carter's pilot study last year showed that whole stalks decompose more slowly than shredded stalks. Preliminary data indicates that this slower decomposition results in more stable populations of beneficial soil micro-organisms throughout the growing season. An additional hypothesis of the study is that these beneficial micro-organisms may have a competitive effect against the plant pathogens. Lyle Carter has assembled a team of scientists who will measure the agronomic and plant pathology effects of the treatments.

The results of this study may turn old notions about tillage and stalk management upside down. It would be one thing to find that whole stalk burial is not detrimental. It would be quite another thing to find that it is actually better for the soil and cotton.

Field test for functionality, durability, and other performance parameters.

One of my concerns when planning this product development process was that we do adequate testing in hard and dry soils. Usually you have to go to Yuma, AZ to do that. As discussed before, we did not have to go to Yuma to find hard and dry soils.

To do this testing, I ran the four-row and six-row machines on as much acreage and in as many locations as I could. This effort ran parallel to the on-farm demonstrations.

Most of this testing was in Pinal County (Casa Grande, Eloy, Arizona City, Coolidge, La Palma, and Stanfield). Some field testing was also done in Pima County (Marana) and Maricopa County (Queen Creek). As close as I can tell, we covered about 700 acres with the four-row machine and about 900 acres with the six-row.

As expected, the principle wearing components of the machines are the plow shares (Figure 8) and root knives (Figure 4). This wear varied dramatically with soil type. In Queen Creek, we did 80 acres with the four-row and had minimal wear. In Stanfield, we did 80 acres with the six-row and wore out a brand new set of knives and shares. When the implement came up out of the ground, the shares were hot, just as if they had been held to a grinder. Farmers in the Stanfield area tell me that it is typical to replace plowshares after every 10 or 12-hour work shift.

We did note some other durability problems and issues, as discussed previously in this report. The problem with the stuffer hub seal not show up until we had about 800 acres on the six-row. Root knives would occasionally break off, usually from hitting rocks. I advised all users that if the Pegasus went "grunch!" to lift it out of the ground and see if any knives were missing.

The functionality proved to be very good. However, this is a precision tillage implement and the driver must keep the stalks coming into a six-inch zone to make the Pegasus work. There are a number of implement guidance systems on the market which automate this task, and I Tom Sawyered Sunco Marketing into lending me two Acura Trak guidance systems to demonstrate. The Acura Traks worked well and vastly facilitated driving at night and in very dusty conditions. The only problems were in getting drivers used to the Acura Trak, and we had some headaches with the stalk-sensing devices of the guidance system.

Farmers usually took the Pegasus to their toughest fields. There was only one instance where it would not work, and that was because we did not have a tractor large enough to pull it. The machine did occasionally plug up. This was mostly due to the hard soil conditions. Sometimes the guidance system was the problem (not staying on the rows).

The machine proved to be capable of plowing through most weedy spots. The clearing disks cut through all of the morningglory vines and bermuda grass. The only weed that would plug it is a large clump of Johnsongrass rhizomes (roots). This was only an occasional problem. There are very good Johnsongrass herbicides on the market, hence infestations of this weed are becoming rare.

The four-row machine consistently plowed five acres per hour. The six-row proved to be capable of 7-8 acres per hour. Thus, in a 12-hour work shift it could finish an 80-acre field while allowing time for a lunch break and tractor servicing. These are very high rates of machine productivity. Since the cost per acre is calculated by taking the hourly operating cost and dividing by the acres per hour, the cost numbers are very attractive. The Pegasus costs around $10. per acre to operate.

The quality of the work the machine did could have been much better with a little moisture in the soil (Figures 26 & 27). However, the same thing applied to all of the other tillage alternatives, so the Pegasus still looked good in comparison. Many farmers who used conventional plows will be rolling large clods around for months to come.

The ultimate proof of functionality will be in how crops grow after using the Pegasus. Most of the farmers who used the Pegasus have planted wheat behind it. I will go back and look at every field to see how the crops are doing. Reports from farmers so far are favorable; some say that the wheat is doing better than with conventional tillage. In Casa Grande, there is a side-by-side comparison of wheat behind the Pegasus and after conventional moldboard plowing. The clods are much larger in the conventional field, and the stand of wheat seedlings is thicker with the Pegasus. This indicates that the Pegasus produces a superior wheat seedbed. I am not worried about any of the wheat, because you can make a lot of mistakes in tillage and seedbed preparation without hurting the crop.

Some farmers will plant cotton after using the Pegasus. This use promises the greatest cost savings with the machine, however there are more opportunities for something to go wrong. In some cases, the Pegasus missed a few cotton plants, either because the field had been re-planted (resulting in two lines of cotton plants per bed) or the guidance system did not hold the implement to the row. It is possible that some of these plants could "stub" or re-grow in the spring. However, virtually all farmers who are going back to cotton with the Pegasus have ripped or plan to rip the beds with a Paratill (a Bigham Brothers product). This should uproot any missed plants, though they would not be well buried in the soil. If we had normal winter rains and temperatures there would not be nearly as much danger of old cotton plants surviving.

I also tested the Pegasus in grain sorghum stubble with mixed results. In some cases, the Pegasus buried the sorghum roots and stalks just as it does with cotton. In other cases, the stuffer teeth passed over root crowns without pushing them under. The solution to this appears to be in designing alternative stuffer teeth with more of a blunt edge. The current teeth are designed to get a hold of a stalk and tap root, whereas sorghum is a grass crop. I'm not going to get sidetracked on that now, but this does hold future potential for the machine.

Task 3: Produce and Sell Pegasus to Farmers.

1. Test market acceptance of Pegasus with one-on-one meetings between Mr. Thacker and farmers.

These are the on-farm demonstrations of the machines. The routine was to bring a Pegasus to the farm on the implement carrier, put it on the ground, hook it and the Acura Trak up to the farmer's tractor (or in some cases a dealer's demonstrator tractor), adjust the machine, and turn the farmer loose with it. In these demos, we plowed one or two entire fields with the machine.

Farmer acceptance of the Pegasus is very encouraging. In most cases, the farmers wanted to keep running it and did not want to put it back on the trailer. They could readily see the time and cost savings the machine offered, and were satisfied with how it buries the residue. Once the drivers got used to the Acura Trak things went smoothly. The machines proved to be reasonably trouble-free and the upkeep requirements are low.

The problem, of course, is that I can't quote a price for the machine because I don't know what it will cost to make. The dilemma is that there is only one time of year when you can demonstrate, and if you don't demonstrate, you won't sell machines no matter what the price is. The only thing I could do is press ahead with the field testing and demos, because it had become clear that the manufacturing and price issues would not be resolved until the season was over.

The plan at the moment is to resolve the manufacturing and pricing issues ASAP. Then the dealer salesmen and I will go back to the farmers to get orders. Many farmers are so conservative that they will not make the purchase decision until after they see a crop growing after using the Pegasus, so we knew that we would have to make some follow-up sales calls anyway.

I should point out that even with an implement carrier, conducting the demonstrations is a logistical nightmare. It is physically demanding. Several parts have to come off a Pegasus to make it fit on the trailer in a street legal manner. Mounting a 450-pound Acura Trak on a tractor is not easy. I often had to diagnose the idiosyncrasies of older tractors to make everything work. We often had to drop dual tires from tractors and adjust the ballast. That is why demonstrations are not very common, and it was a major limitation to how many demos we could do. But demos are very effective, and we will rely heavily on them to make our market penetration.

The general market conditions for the Pegasus:

The market research I did a few years ago is still on target. Farmers want a tillage system that cost less, is faster, easy to maintain, reliable, and does a good job of burying the crop residue. Every tillage system now available flunks one or two of those criteria. There is a lot of frustration out there with the current state of the art in cotton tillage.

One thing that surprised me was one farm equipment salesman's reaction to the Pegasus. He was upset at the idea that farmers would be spending less money on tillage, because this would cut into sales of conventional tillage implements and high horsepower tractors. This underlines the fact that the competition is not only the other "alternative" tillage systems, but is mostly conventional tillage. That is what over 90% of the farmers are now using.

The demonstrations proved that the market positioning for the Pegasus is distinctly different from the other alternative tillage systems. The Pegasus delivers good residue burial, which sets it apart from the root pullers (Sundance and the like) and the rip-list systems. Most farmers will not consider those things because they just won't tolerate the poor residue burial. Most will consider a Pegasus. This means we can sell to a large segment which the other alternatives can't touch.

I demonstrated the Pegasus with a Sundance System owner (the guy in Casa Grande with the 15-inch crescent wrench), and he liked the Pegasus better. Other Sundance owners remarked at how the Pegasus did a better job that three passes of the Sundance. I never realized that farmers made multiple passes with those things, but they do to get the residue buried enough to allow them to plant wheat.

We have some marketing challenges:

There are some marketing challenges relating to tillage and seedbed preparation as a system. Using the Pegasus is precision tillage, sometimes it is called controlled traffic farming. For a farmer to maximize the benefits of the Pegasus, he may have to change some of the other operations. A machine guidance system becomes almost essential. Subsoiling needs to be confined to the row, not done all over the field as with conventional tillage. Preplant herbicide incorporation should be confined to the tops of the beds and should be combined with the seedbed preparation pass. Many of the farmers I demonstrated with are already doing these things, because they are all cost saving technologies by themselves. The problem is that many farmers are not doing these things, and *we have to recognize that as a marketing challenge.*

As an example of this marketing challenge, I have enclosed a "Cotton System" brochure from Bigham Brothers, Inc. This and similar tillage systems have virtually taken over on the Texas High Plains. It is generically called "stale seedbed" tillage. Bigham Brothers has been marketing this system in Arizona and California for the last three years with very limited success. The reason is that this system does not get rid of the our large and robust cotton stalks (on the High Plains, stalks only get pencil-sized, and they freeze to death in the winter).

If you will open the "Cotton System" brochure, four steps are shown. If you use the Pegasus after shredding (or bury whole stalks), and then do everything else in the brochure, you have a complete and cost-saving tillage system for the West. We have run the Paratill behind the Pegasus and it is an excellent combination. Step #4 in the brochure is important, because the farmer will need to apply herbicide to existing beds. Most now apply herbicide to flat ground before re-bedding. One reason I wanted to work with Bigham Brothers is that we could work to each other's mutual benefit in marketing our equipment. Dealer salesmen who are familiar with the Pegasus were quick to see these additional sales opportunities.

Lyle Carter verifies the troubles Bigham Brothers has run into trying to market their "Cotton System" in the West. He has been working on controlled traffic tillage in western cotton since 1956. Lyle points out that the reason it has not been widely been adopted in the West is that we never had a reasonably efficient means of getting rid of the stalks. He believes that the Pegasus will prove to be the solution to getting rid of the stalks, and that controlled traffic cotton farming will finally take off with the introduction of the Pegasus.

The point of this little treatise on marketing challenges is this: Even though the Pegasus is the linchpin technology in making controlled traffic tillage attractive in western cotton, farmers can't fully capitalize on it without implementing a complete controlled traffic farming system. The first buyers will be farmers who are already using the other features of controlled traffic tillage. Hopefully, their neighbors will observe and learn from these early adopters. Otherwise, we could have a big market education problem.

Establish relationships with dealers.

In spite of the fact that we have not set any prices and therefore can't ink in any orders, I can report some progress on this. Pinal County has four farm equipment dealers; Central Machinery (Deere), M&S Equipment (Case), Keith Equipment (Case), and Bingham Equipment (Ford - New Holland). Central and M&S both have taken an active interest in the Pegasus, and their salesmen were of great assistance in helping with the demonstrations. Keith and Bingham are absolutely moribund and are definitely not what I am looking for in a dealer. Two out of four isn't bad.

The interest at M&S is especially high. I would start a demonstration and hang around the side of the field, while the salesman would take off in his pickup. Soon he would return and then five or six farmers would show up. We got a lot of good exposure.

Originally, I thought we would have to sell a few machines direct to farmers to prove to dealers that it can be done. However, the level of interest and cooperation from M&S

and Central indicates that this will not be necessary. I believe that in view of the efforts they made, selling machines direct to farmers would probably just louse up the dealer relationships.

During the one demonstration in Maricopa County, I contacted Arizona Machinery Company (Deere) to see if they may be interested. Two of their salesmen came to the demo, and returned to the firm with some information I provided them (they have a bureaucracy). We plan to focus a marketing effort in Maricopa County in 1996. The other major dealer in the region is Keith, and with rumors flying about their financial condition we will steer clear of them if we can work with Arizona Machinery.

The Farm Equipment Manufacturer's Association is advising us members that we should have contracts with dealers (many just sell to dealers on trade credit with no contract). We had a lawyer draft a contract, but this issue will remain on the back burner until we resolve the manufacturing question.

That is all the progress I can report for the last quarter of 1995.

As soon as this is in the mail, I will go to work to develop the financial reports and file for reimbursements and an advance on the grant. Had it ever rained, I would have sat in the house and filed for reimbursements and advances long ago. I felt compelled to test and demonstrate as much as possible, so I stayed out in the fields with the farmers.

Of course, the manufacturing question now looms as our biggest problem. We will shop this around in earnest. No matter who we deal with, we will have a lawyer draft a contract to spell out everything, including some very detailed specifications on materials, manufacture, and quality control.

Sincerely,

Gary W. Thacker
President/CEO

enclosures

Copies to:

Office of Placement and Administration, HR-561.21
DOE - OSTI

Figure 1. Forward view through a pair of plow units, where a large volume of soil flows through. The 18-inch clearing disks are in front of the plow moldboards.

Figure 2. Additional 20-inch disk blades added in tandem with the 18-inch clearing disks. The additional blades reduce the size of clods when operating in hard and dry soil.

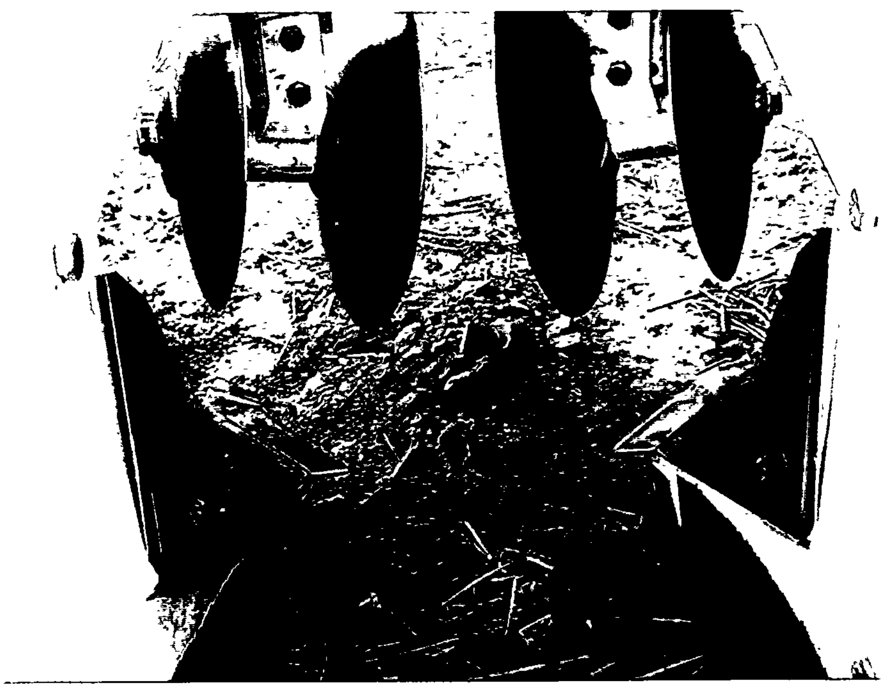


Figure 3. Driving lugs added to the stuffer disks to prevent stalling in hard and dry soil conditions.

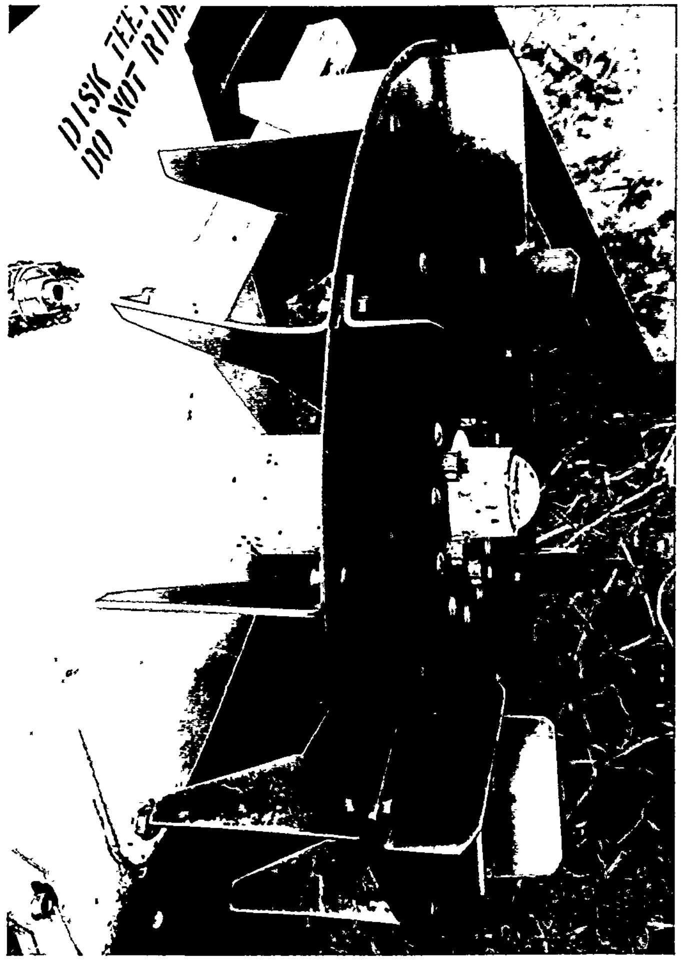


Figure 4. Landside view of a plow unit, showing the root knife at the bottom. The triangular stalk deflector is also shown, this deflector funnels stalks into the stuffer teeth.

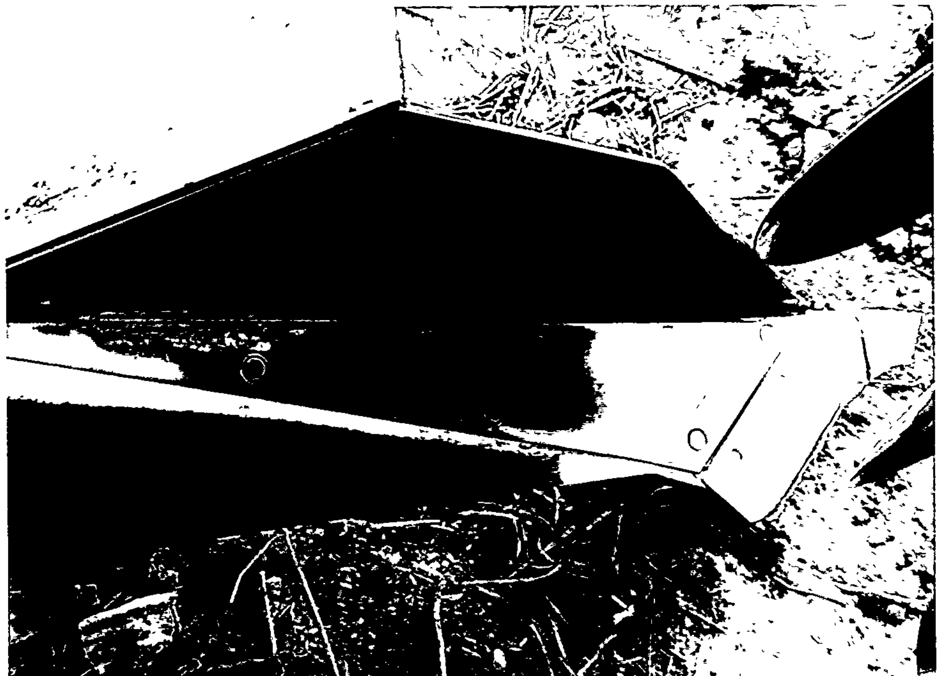


Figure 5. Profile of the moldboard. This is the 2-piece moldboard made from 3/8" AR400 plate. The rust sopt shows where a soil body was carried.

Figure 6. The one-piece moldboard made from 1/4" AR400 plate. The crack in the deep bend is evident here, as well as the poor fit-up behind the plow share. The rapid wear from the leading edge of the upright protion is also evident.

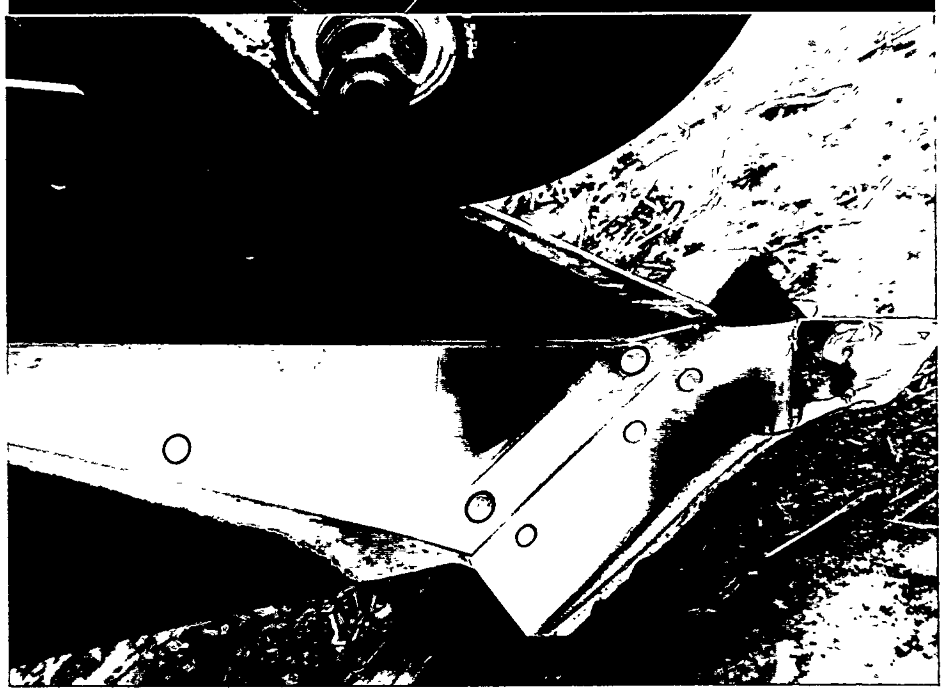


Figure 8. The better fit-up of the 2-piece moldboard to the share. Worn hardfacing on the high wear area is also shown. A chromium edge may greatly extend wear life in this area.

Figure 9. The 18-inch clearing disk and mounting assembly.

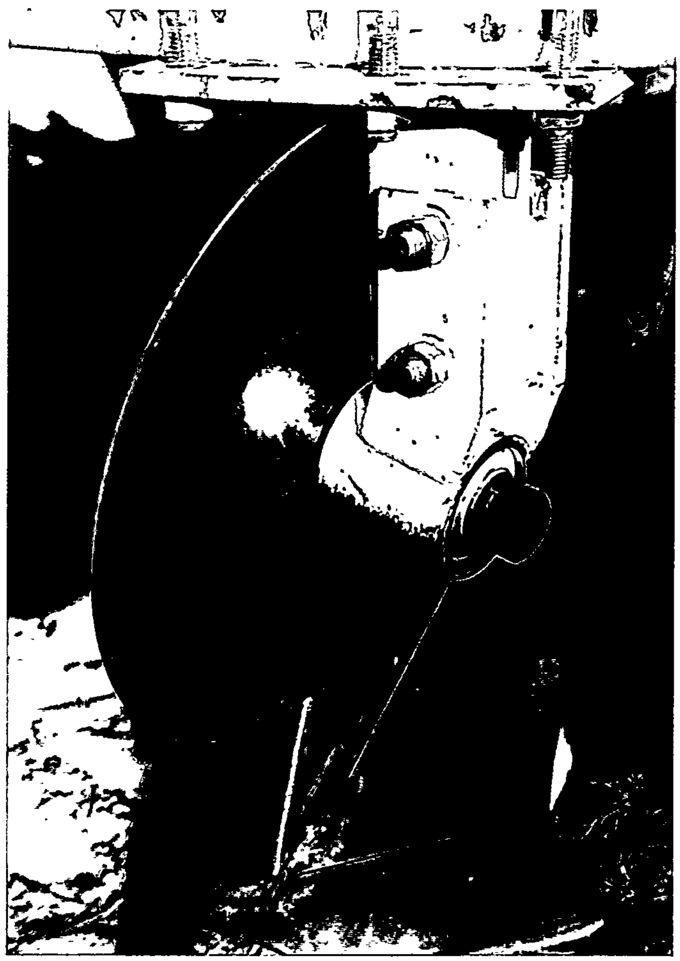
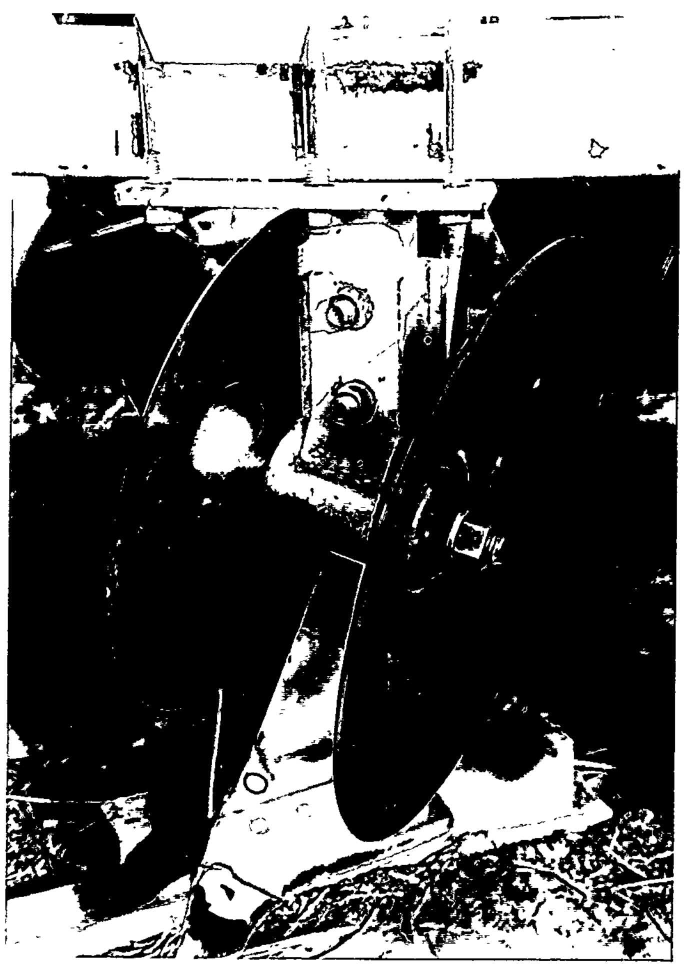


Figure 10. The clearing disk assembly with the additional 20-inch disk blade for hard and dry conditions.



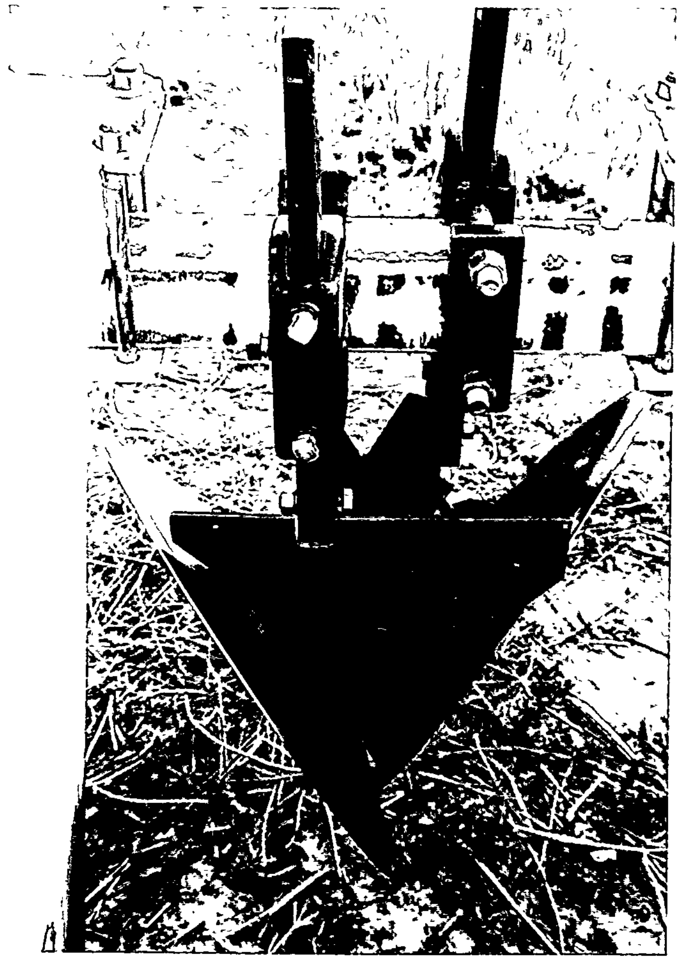


Figure 11. A pair of disk bedders positioned between a pair of plow units. The debris shield between the disks is essential to keep the disks turning free.

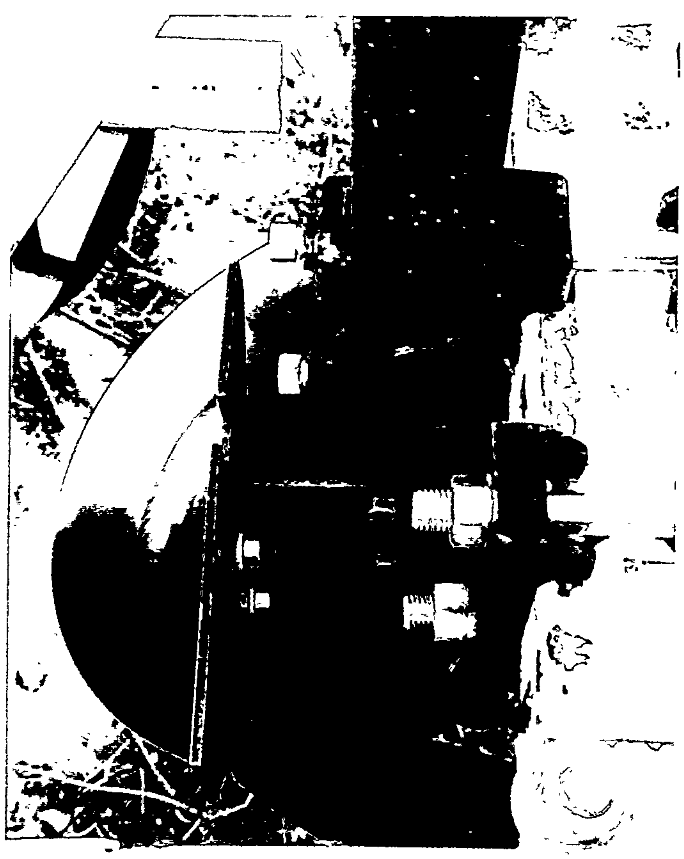


Figure 12. Mounting of the debris shield. Carriage bolts in slotted holes make this shield adjustable.

Figure 13. A pair of disk bedders which are not positioned betweed opposing plow units. These disk bedders only re-run existing furrows, hence do not engauge enough soil to require a debris shield or scrapers.

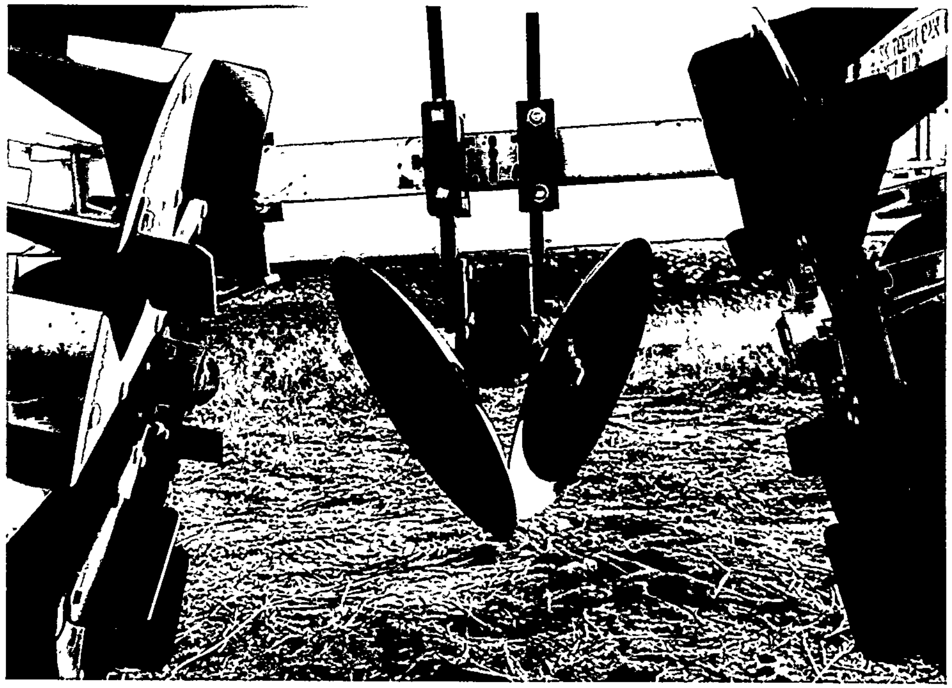
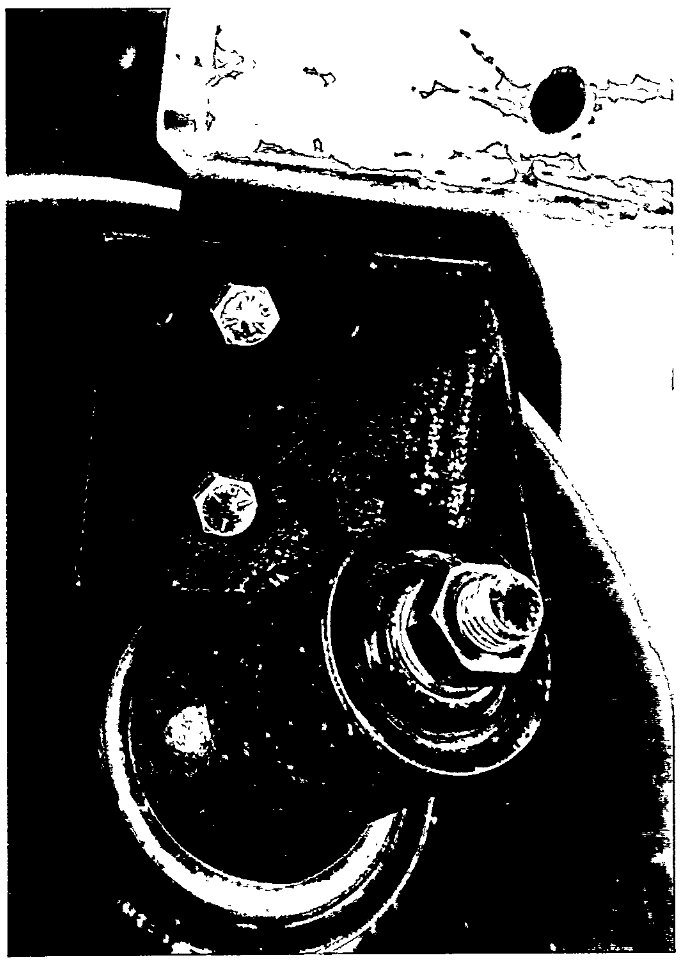


Figure 14. Extra holes were punched in the flag plates of the disk bedder hub assemblies, these holes can be deleted in production. The size of the flag plate can also be reduced slightly.



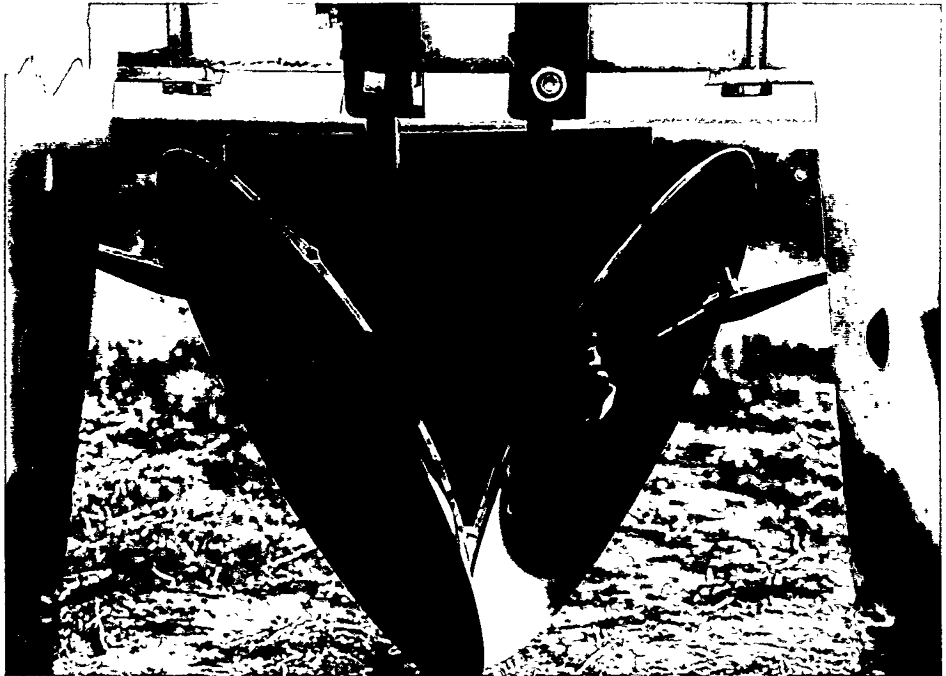


Figure 15. View of a pair of disk bedders positioned between opposing plow units and equipped with scrapers.

Figure 16. Mounting of the scraper for a leading disk bedder.

Figure 17. Mounting of the scraper for a trailing disk bedder.

Figure 18. Profile of the stuffer disk and teeth.

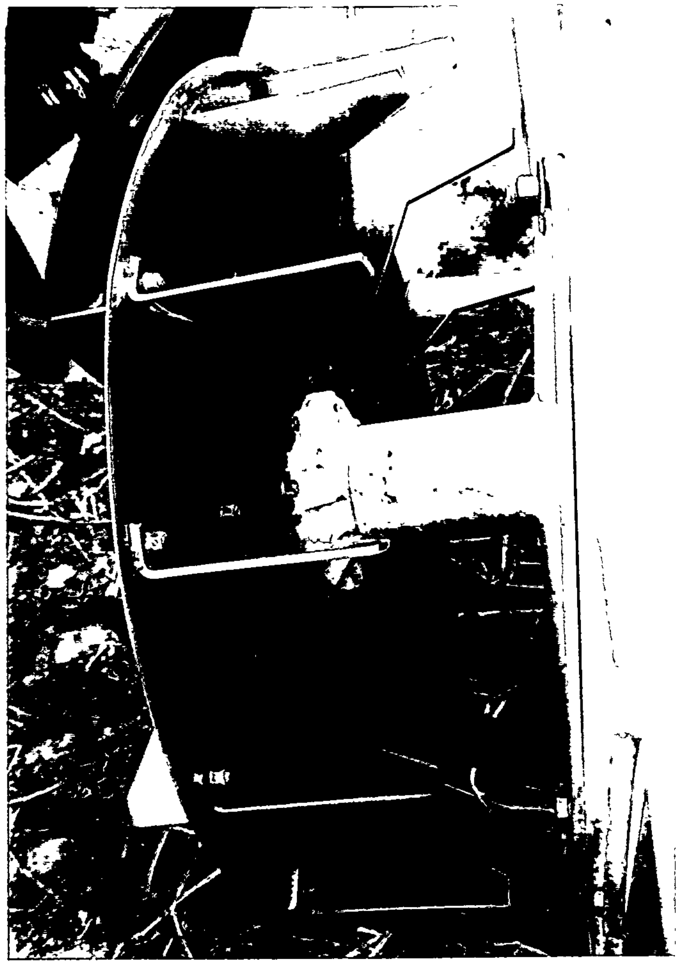


Figure 19. Scraper for the stuffer disk. Slotted holes and carriage bolts make the scraper plate adjustable for both height and angle.

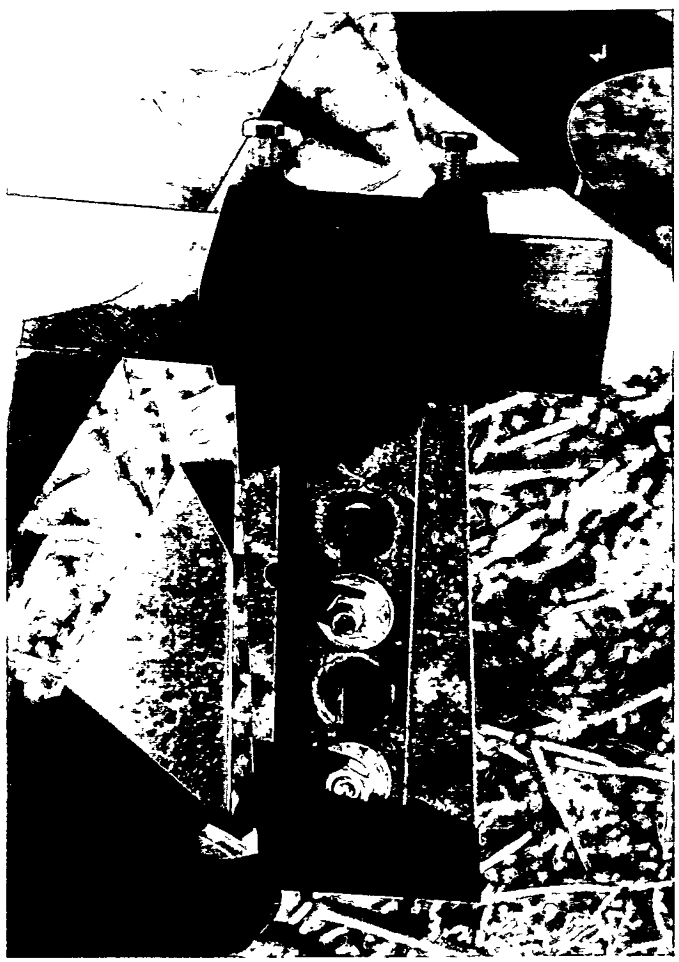


Figure 20. Rear view of the stuffer hub mount assembly. The 5/8" pivot bolt can be seen at the front. The 3/4" bolts in slotted holes at top and rear botton (seen under the 2x2" scraper standard) allow for height adjustment of the stuffer disk.

Figure 21. Front view of the stuffer hub mount assembly.

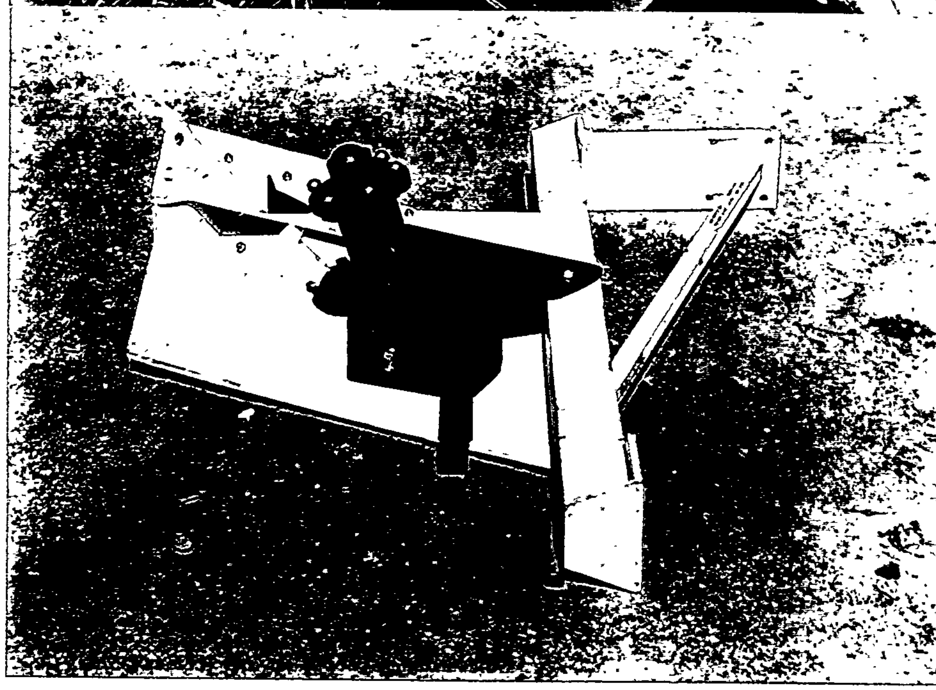


Figure 22. Plywood mock-up of the plow unit, shown with a prototype stuffer hub assembly.

Figure 23. Front attaching point of the plow unit. This is bolted through the clearing disk mount, shown below the 4x7" toolbar. U-bolts and the toolframe mast are at the top.

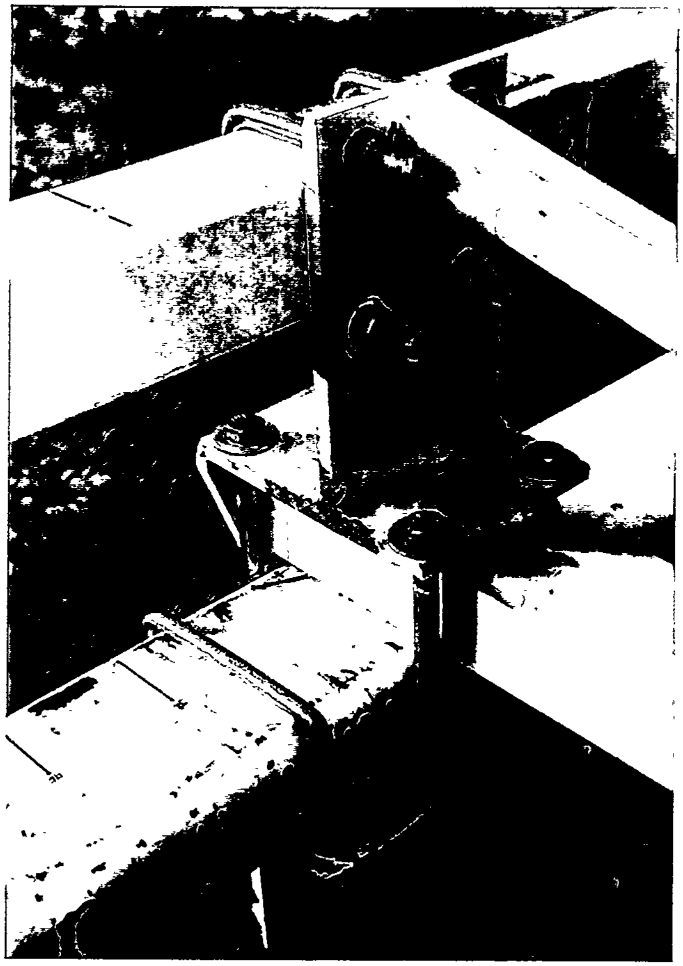


Figure 24. Rear attaching point of the plow unit. The 1/2" plate will be deleted, and 2 U-bolts will be used in place of the four hex bolts.

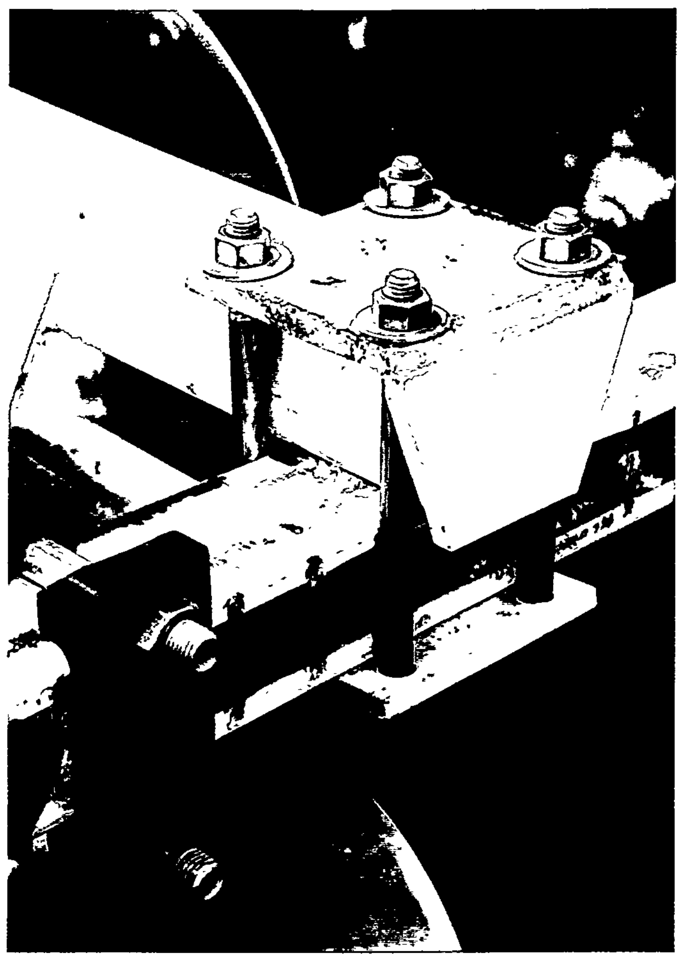


Figure 25. The Donahue implement carrier in the unloaded position.

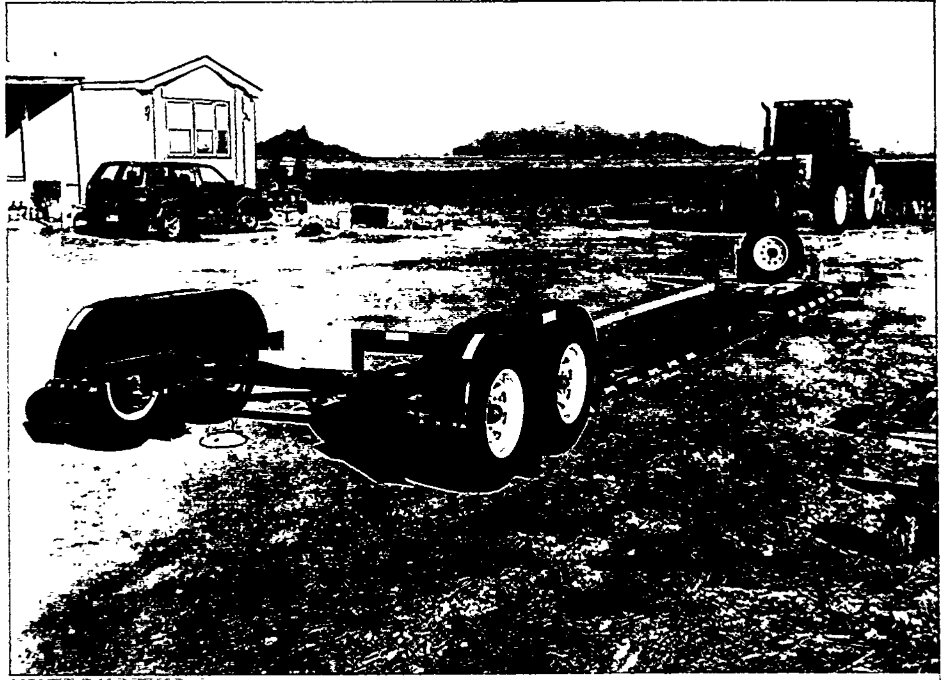


Figure 26. The four-row prototype at the Sossaman Farm in Queen Creek, AZ.

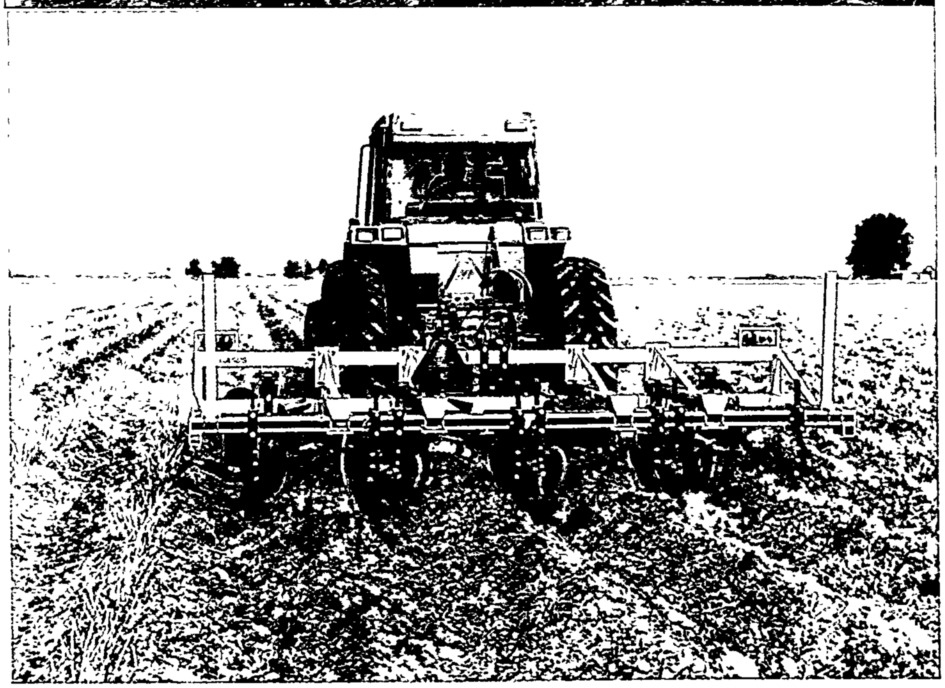
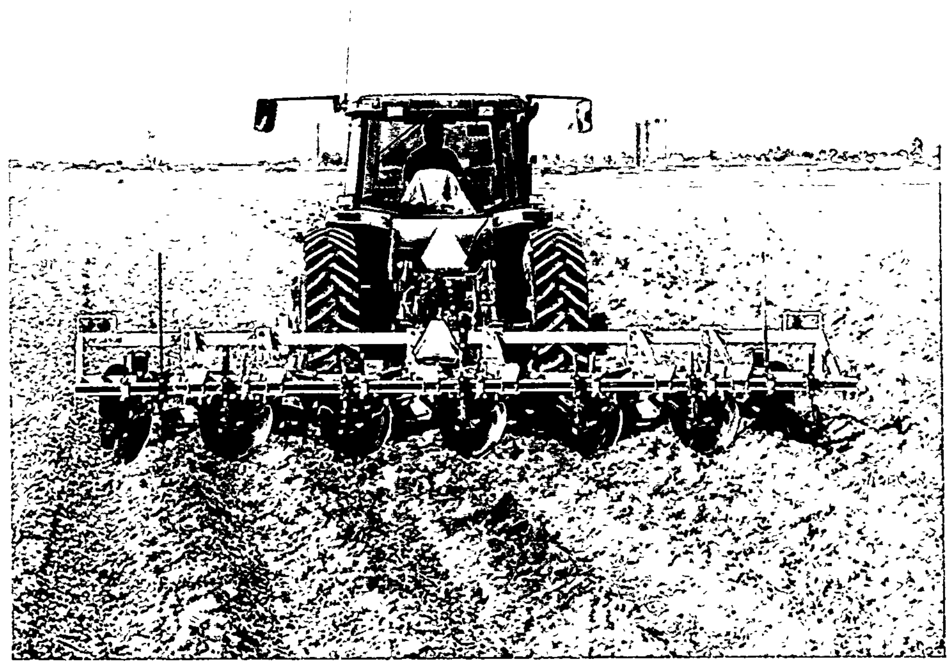


Figure 27. The six-row prototype at the Hartman Farm in Stanfield, AZ.



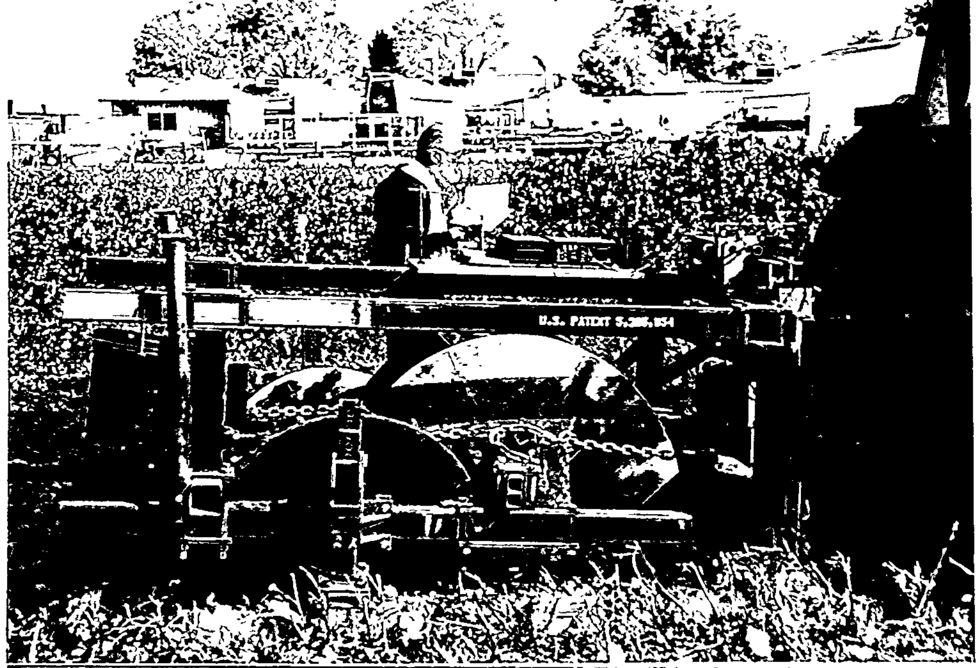


Figure 31. Lyle Carter with the disk prototype, plowing under shredded stalks.

Figure 32. Plowing under shredded stalks with the disk prototype. Lyle Carter is measuring implement speed and Joe Chesson is measuring draft.

Figure 33. Plowing under shredded stalks with the moldboard prototype.

Figure 28. Plowing under whole stalks at the USDA-ARS Cotton Research Station in Shafter, CA with the breadboard "disk" prototype. ARS engineers Lyle Carter and Joe Chesson are taking speed and draft data.

Figure 29. Plowing under whole stalks with the preporduction "moldboard" prototype. ARS technician Vic Penner is driving, engineer Joe Chesson is collecting draft data.

Figure 30. Plowing under whole stalks with the moldboard prototype.

The Cotton System.

Stale Seedbed? Reduced Tillage?

If you are looking for new solutions to old challenges in cotton production, we might just have the answers you are looking for.

Bigham Brothers has developed a system approach to crop management during the dormant (Fall to Spring) cotton production season. It has proven successful to reduce passes through the field and prepare cotton ground for maximum production. The Cotton System also allows flexibility to make minor or drastic modifications to equipment or timing of operations to suit your individual needs, soils and crops. For more information look inside.

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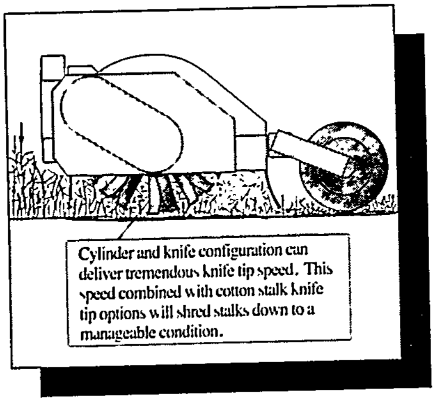
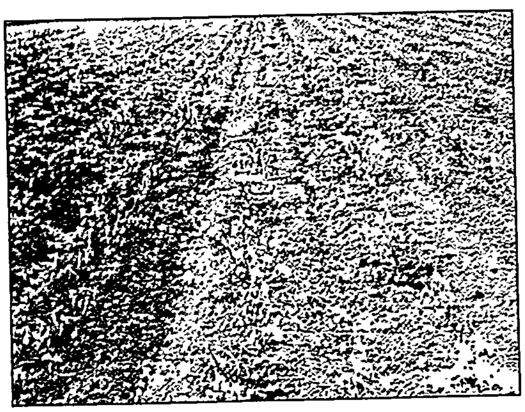
1. Shred Stalks
with a Flail Shredder.

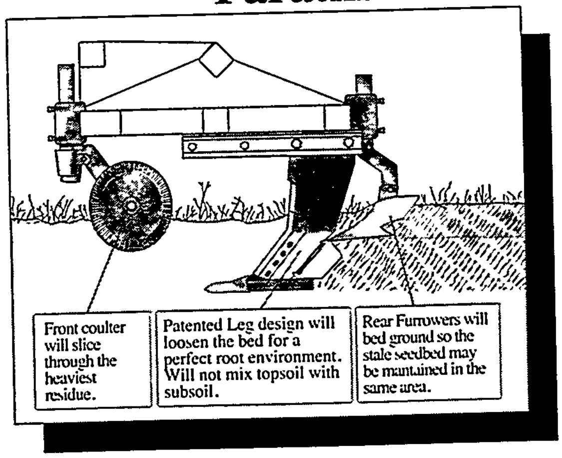


After cotton is harvested, a flail shredder may be used to cut stalks into a manageable condition. Flail shredders provide superior cutting action in heavy residue. Cut residue will protect the soil surface against erosion. In many cases, this practice is currently or will be required to comply with conservation programs.

Flail shredders may be equipped as three point, semi mount or pull type packages. Models are available in complementary cutting widths. Specific knife options and rotor speeds equip shredders for optimum performance in cotton stalks.



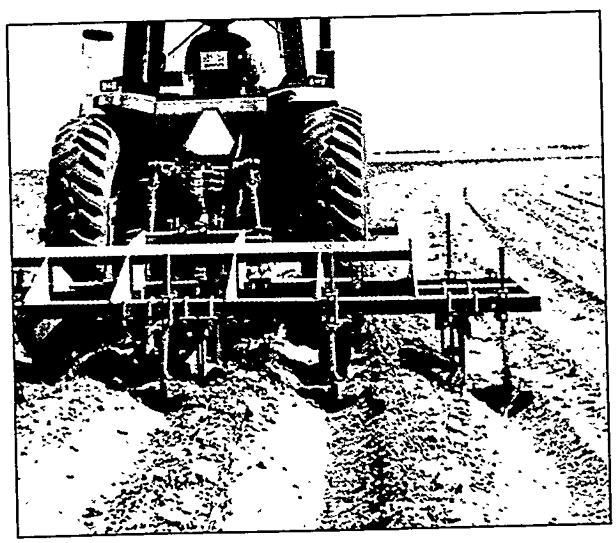
2. Deep Tillage
with Bigham Brothers Paratill®

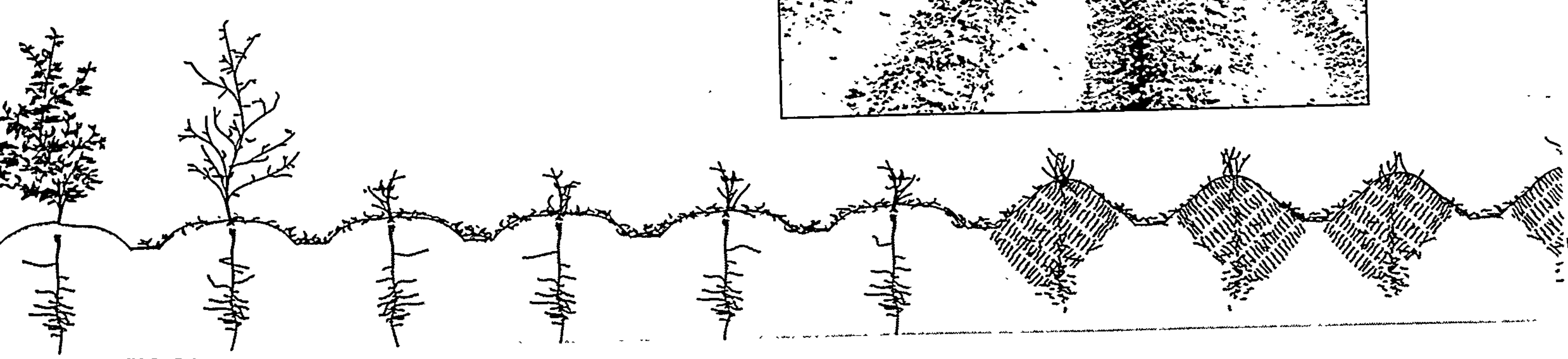


Paratill® is the cornerstone of the Cotton System. Paratill® will break up compaction without destroying soil structure. The patented legs bent at a 45° angle will lift subsoil, allow it to fracture under the natural planes of weakness and settle. This loosening will encourage root development, enhance moisture absorption and improve soil drainage. The gentle lifting action will not mix topsoil with subsoil, create clods, bury residue or mandate additional tillage trips.

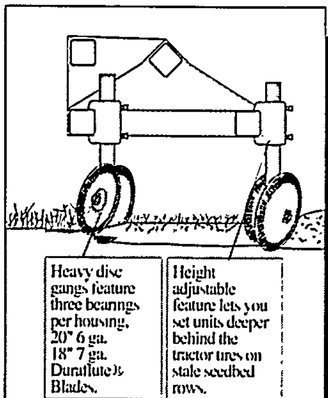
The Paratill® has gained quite a reputation in cotton country, particularly in the Delta. This tool has provided substantial yield increases with a reduction of required tillage passes.

Paratill® is available in four through twelve leg models. In cotton operations, most are set up for zone loosening and are equipped with rear furrowers to designate crop and traffic zones.



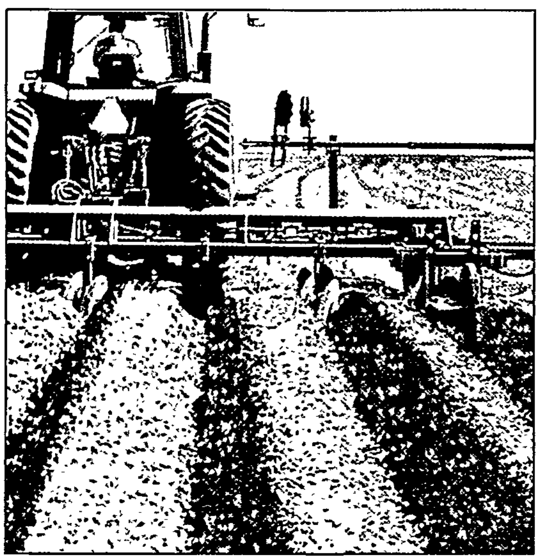


3. Rebed with Bigham Brothers Disc Bedder

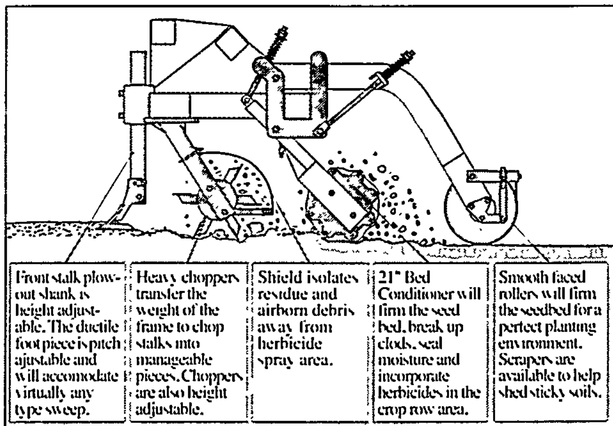


Bigham Brothers Disc Bedder will reshape beds and form consistent twin rows for typical six, eight, ten or twelve row patterns. The disc bedder will pull easier and can be operated at higher speeds than a conventional middlebuster type lister.

Disc bedders are available on rigid or folding frames up to 42'. Configuration of gangs on double bar frame provides exceptional soil and trash flow and extends flexibility in changing gang spacing.

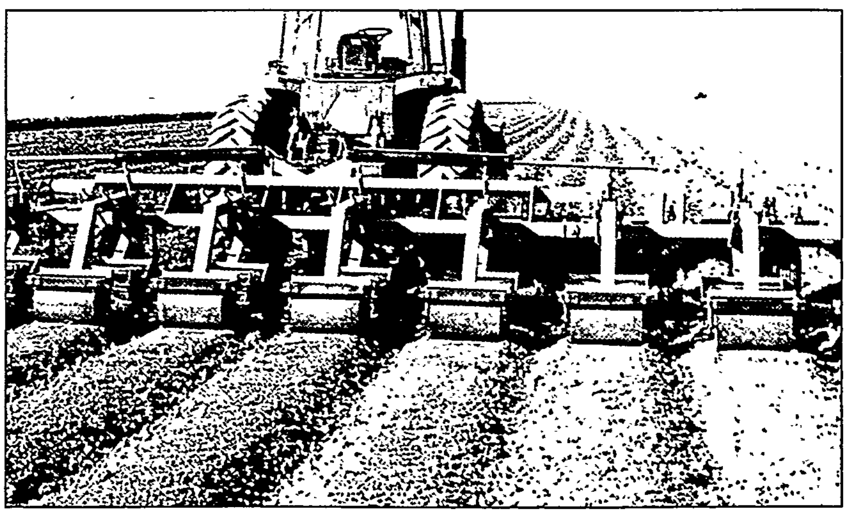


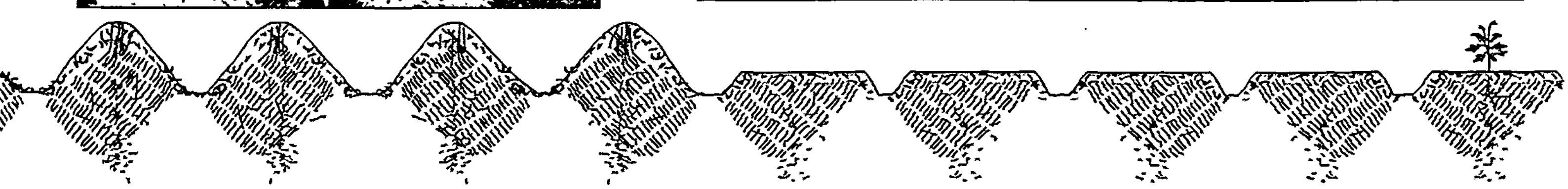
4. Prepare Seed with Bigham Brothers PrepMaster®



The PrepMaster® executes several operations critical to planting in one field pass. Front sweep and chopper will cut stalks into small pieces, distribute the buried stalks and knock down the crown of the bed. Center basket with spiral blade will incorporate chemicals and condition the top of the bed. Rear roller will flatten and firm the seedbed.

There is often a limited window of opportunity to get crops planted with the proper moisture conditions. The PrepMaster® process prepares the soil for planting and eliminates scheduling problems for multiple pass field operations between seasonal rains. This tool will effectively band chemical in the crop area. The practice of banding herbicides as opposed to broadcast application can substantially reduce production costs and keep herbicide run-off to a minimum.





The Cotton System is complete from harvest to plant. Stalks have been shredded in the fall. Over the winter the remaining stalk and root system have decomposed and become brittle to work into small pieces that can be incorporated into the seedbed. Deep tillage with the Paratill has prepared a loose subsoil environment for crop root development. Reshaping beds with a disc bedder has matched up twin rows and refined the contour of the bed. Prepmaster has completed the cycle, forming a perfect seedbed with herbicide banded down the tops of beds.

Bigham Brothers has developed this system with a great deal of input from producers whose primary objective is to reduce the number of passes through the field. We have worked to combine operations wherever possible and still get cotton ground properly prepared.

The Cotton System can easily be modified to fit your specific guidelines. The component nature of our equipment allows adding or subtracting pieces and parts or changing the row spacing. We feel it is the most flexible system of farm equipment available and has been specifically designed with cotton production in mind.

If you would like more information on the Cotton System or any items in our complete line of equipment please contact us. We will be happy to discuss the system or send information to you.

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