Converting an Allis-Chalmers "G" Cultivating Tractor Into an Electric Vehicle

(A USDA Funded SARE Grant: **FNE03-472**)

Ron Khosla • 205 Huguenot St • New Paltz, NY 12561
(845) 256-0686
ron@flyingbeet.com
www.flyingbeet.com/electricg

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Following are step by step instructions for converting your old gasoline Allis Chalmer's "G" cultivating tractor into a smooth running, non-polluting, energy efficient, whirring and humming electric miracle worker that will seed and weed your fields for pennies a week -AND with even more power than the original gasoline version!

I am not a professional manual-writer, so if you find lacks or mistakes in this manual, email me at ron@flyingbeet.com and I'll be happy to answer your questions personally. I'll also update this manual on-line based on your questions (and suggestions) and in that way we will finally end up with a really solid document!

Therefore, if you are reading this in hard copy form, try to check out the webpage version of these instructions to see the latest updated information, clarifications and improvements. The website is **www.flyingbeet.com/electricg**.

It's recommended that you follow the instructions in the order presented (and to quickly skim through them) before you start the project. The skill level required to complete this conversion is VERY low, and the payback in gas saved, the "coolness" factor to your customers, and time saved in tune-ups makes it completely worth it!

Index

Introduction	Page	2
Parts you need to order	Page	3
Taking apart your existing tractor and preparing it for the conversion	Page	5
Parts that need to be machined (Optional step!-For extreme do-it-yourselfers only!)	Page	8
Actual installation instructions	Page	14
Appendix I: Our solar panel experiment and learning experiences	Page	30
Appendix II: Hard-learned experiences caring for batteries	Page	33
Appendix III: Notes, disclaimers, thoughts and potential concerns	Page	35
Appendix IV: Acknowledgements and Thank You's	Page	37
Appendix V: Final Report to SARE	Page	38

Introduction

The Allis Chalmers "G" Cultivating and Seeding tractor was built in the late 1940's and 50's. It is really an unusual looking tractor, because the engine is in the back, allowing excellent an unobstructed field of vision of the implements, which are mounted on the BELLY of the tractor. Toolbars and implements are easily and quickly changed (especially if you drop the implements onto a dolly which can be rolled in and out).

The tractor doesn't have a 3 point hitch system, and it's PTO is non-standard... This is not a tractor most people are using to plow or disk fields. It's really magic is when it is used for seeding and cultivating.

It's nearest competitor is probably the Farmall "Cub", but... for me, the "G" is far better, simply because you are placed so close to the seeding and weeding implements you are using, allowing you to catch seeding snafu's and get closer in your mechanical cultivation.

Although they haven't made Allis-Chalmers "G" tractors in decades, you can find them for very cheap, often abandoned in back fields, with long-since seized motors. (We advertised in the local paper to get one and "asked around" for another).

We paid under $1000 for both our "G" tractors. One actually had a running engine which I wasted a lot of time constantly fiddling with before I gave up and converted it to electric. Now, with these instructions, YOU TOO can rebuild an old stinky "G" into an efficient electric tractor that runs on pennies a day for decades longer.

Even if you are sure that you don't know anything about mechanical objects, you CAN do this conversion. Once you have the parts purchased and machined, it will take you a very short day at most to put this together. There are less nuts, bolts and parts to putting this together than there were with the porch-swing kit we just got from Home Depot. Now THAT was a job! Best of all, you'll never have to fiddle with tuning a gasoline engine again!

I've tried to write this as simply and clearly as possible using only plain English. That's partly because *I* don't know the technical terms for mechanical parts either. When I built our first electric tractor, I had NO EXPERIENCE working with electric motors, and only limited experience working on gasoline engines. That first tractor is well into it's third year now, and still working beautifully on a full-time basis, with NO tune-ups or adjustments necessary (unlike it's earlier gasoline incarnation!)

The tractor you'll be building from these instructions is even more bullet-proof and less-complicated to put together than our first machine. There are fewer machined parts, too, so if something DOES eventually break (we are farmers, after all) it should be even easier to order a bolt on, off-the-shelf replacement.

If you get stuck or confused, please don't hesitate to EMAIL ME (calling isn't so wonderful). I'll try to incorporate the better questions and my answers into this website to make it better and easier for future folks to follow.

Converting Your Old Allis-Chalmers "G" Cultivating Tractor to an Electric Vehicle

"Off-the-Shelf" Parts List

Following is a list of parts we ordered to do this conversion with 2003 pricing and suppliers.

Parts ordered from:

ELECTRIC VEHICLES OF AMERICA, INC.
Phone: (603) 569-2100, Email: EVAmerica@aol.com, Website:

We lucked into getting our parts from Bob Battson at Electric Vehicles of America. I'm sure there are other places that you could order these parts from because they are pretty standard, but I didn't see them cheaper elsewhere on the internet..

Although I have to admit that I chose EVA because of pricing, MUCH more important than the low prices ended up being the service he provided. Bob definitely doesn't look at his job as just selling parts. He answered countless phone calls with even my stupidest questions as I was going along (I knew NOTHING about electric vehicles). I did try to read the instruction manuals that came with the parts we ordered, but maybe because I had no background in it, I got stuck a lot, and he never seemed to get annoyed with walking me through what I needed to do verbally. I know he works with a lot of school groups, and I generally felt like I needed handholding at a very elementary level, and he seemed happy to provide it.

Maybe I'm going on too long about how great Bob is, but... his service was very important because, unlike with a gasoline engine, you can't just call up any local service technician if you have problem. Things don't go wrong as often with electric systems, and they are generally easier to fix, but... if you DO have a problem you want someone that can be there immediately to walk you through troubleshooting, and he's definitely done that for us (even years after buying the parts).

DRIVE SYSTEM
A00-4009 Advanced DC Motor - (24-72V and 2-12Hp) - $475.00
AllTrax AXE-4844M Controller - (with 400 Amp limit) - $295.00
PB-6 Potbox - $80.00
Albright Contactor SW-80 (You should get an ALL WEATHER one, we didn't) - $55.00

BATTERY SYSTEM
Qty 4 Trojan 12 volt batteries -30XHS - @ $85 each
Lester Battery Charger, 115 VAC Input, 48 VDC Output - $375.00
Battery Terminal Protective Covers - $1.50 each - $12.00
1Ga Cable Package - 12 ft black - $80.00
heavy duty battery lugs (25) and heat shrink tubing (3 ft)

OPTIONAL INSTRUMENTATION (we don't have these items on our first tractor, and don't miss them)
Curtis Fuel Gauge 48V - $110.00
Ammeter 0-200 A Westberg - $55.00
Shunt for ammeter 50mV 200A - $30.00

Total Price: $1325 per tractor in essential parts (plus charger).

For the first two years, we used a cheap $25 12 volt battery charger from Walmart and charged one battery at a time. It was Bob's suggestion because he knew we were trying to do things as cheaply as possible. It definitely worked, but now that we have the "real" charger (listed above) that does all the batteries together at higher amps... and equalizes them all... it definitely feels worth the price. It's better for the batteries too, in the long run.

Parts ordered from **Niekamp Tool Company (phone: 845-338-7959)**
(Note: Instead of buying the pieces in from Niekamp Tool Company, you can instead choose to have all these pieces made at a local machine shop OR even machine them yourself. We've provided specification sheets . However, it is CHEAPER to have Niekamp Tool Co. do it for you, because they were involved in the initial design and have the experience (and more importantly the templates) to punch these out very quickly now.

Prices will vary drastically based on the cost of steel... prices are for estimation purposes only. AC-G Pulley Stub $85
AC-G Clutch Plate Adapter Ring $45 AC-G Motor Plate $45
AC-G Bell Plate $55
AC-G Bearing Distributors Kit (same price as below)
AC-G Nut and Bolt Pack $12

Total (not including Bearing Distributors parts): **$242.00**

Parts ordered from **BEARING DISTRIBUTORS mail order company, 800-784-2550**
You do NOT need to order these parts unless you want to machine the above listed plates, stub and adapter yourself. If you plant to order the machined parts from Niekamp Tool Company (recommended) they will order these pieces for you, fit them to their machined parts, and then ship you the pieces pre-assembled and ready to bolt on to your tractor. I am listing these pieces here JUST for people that want to do all the metal work themselves.

1.5" wide Timing belt - *part no. 240H150* $11.64
7/8 inch bushing between shaft on the electric motor and the motor-pulley - *Part no. 11008* $7.40
Smaller Pulley for motor shaft - *Part No. P16H150-110 8* $21.64
Larger pulley for tractor side - *Part No. P32H200-2517* $41.04
Needle Bearing (11/16 inch, by 15/16 inch by 3/4 inch) - *Part no. JH1112* $4.70
Zirc Fitting - *Part no. Zirc Fitting 1/4-28* $0.50
(qty 2) Rubber seal bearings - Part no. 6007 -2NSE $27 each.

Total Price: $140.94

From your local auto-parts store (or radio shack) you also need to buy one small $5 on-off switch, about ten feet of single-strand insulated 14 gauge wire (as is used in automotive wiring) and what Radio Shack calls "Quick Disconnects" ($1.69 for a pack) that crimp on to one side of the wire and will slide on to the small terminals off your Controller.

Step 1: Taking apart the Original Tractor

(Estimated time: About 2 hours)

To start with, you need to remove the gas tank, engine and original battery box from the tractor.

Depending on how corroded things are and whether or not you have a torch to deal with such corrosion this could take an hour or more, but it should go quickly.

Here's how our the old Allis looked after we removed the gas tank, but before we started to take off the engine. Not pretty!

Taking off the gas tank and battery box are especially and obviously easy and good places to start (especially if you may need a torch later... you want that gas tank FAR FAR away!)

Carefully remove and **save the throttle control rod** that lets you adjust the gas flow (connects from underneath the seat to the engine) because we'll be using that again.

. Also, don't forget to unscrew the clutch bar (see picture). Because this is an electric tractor, there is no reason to HAVE a clutch. A gasoline engine is always on and spinning, so you need a clutch to disengage the spinning motor from the gears, but an ELECTRIC motor is actually OFF when you aren't moving, so a clutch plate is completely extraneous.

Unscrewing the clutch lever.
The gear cog you see above ran the original hydraulic pump (more on that later.)

That being said, PLEASE BE CAREFUL when actually removing the engine from the clutch housing because we will be using the original clutch plate to tie the new electric motor to your original transmission. This saves a BUNCH of purchases and machine work! Of course we'll also be using all the old engine mounting holes and nibs, so don't beat be beating on things TOO hard... or let bolts break off in their holes, because we'll NEED those holes later!

You shouldn't have to do it yourself, but we actually removed the clutch housing from the tractor and THEN remove the engine from that, then re-bolted on the clutch housing to arrive at the stage you are seeing in the bottom picture.
If you aren't sure what I mean by clutch housing, look at the engine. It's one obvious "PIECE" that bolts on to another PIECE that then bolts on to the body of the tractor. We just want you to remove the ENGINE itself. You don't have to remove that housing like we did. though you can if you want to for fun.
I took ours apart because I really wanted to see inside since this tractor had been sitting around for so many

(Back View of the tractor, looking into the open clutch housing after unbolting the engine.)

years completely unused.
It's amazing that after 50 years of combined use (and abuse the last 10 or so) all the inner gears looked so perfectly unworn... There was some collected sludge that I sort of dug out, but otherwise it looked like it was ready for another 50 more years.
We scraped off the remains of the old gasket and used form-a-gasket stuff from NAPA to remake a gasket and rebolted the housing on. You shouldn't have to do this... I'm just mentioning it because it was sort of interesting to see this sad, old tractor that people had rolled down hills into trees... with rotted tires and peeling paint and bent steering arms look so pristine and almost factory fresh on the inside!
Though I'm saying being careful... even after removing the bolts, I had to beat on the engine a bit to get it separated from the clutch housing... I actually hit it with a sledge hammer (with a 2x4 to cushion the blow) and I put pallets under the back to sort of catch it when it did start to come off. Then Kathryn and I bullied it off and away from the tractor and into the bucket loader where I dumped it temporarily about 20 feet from our front door... where it still sits as the first thing people see as they walk up to the house. This neighborhood was getting too snooty for my tastes anyway.
After the engine is off, look at the clutch plate, which is the grey plate thing on the tractor end of the engine. It has what looks like the inside of a PTO shaft in the middle of it. **Save this unit!**. Just unbolt it from whatever it's attached to EVEN if it looks like it's in bad shape. It will save us from having to make or buy something like it later.

View from INSIDE the clutch housing. Look to the lower left to see the small aluminum scrap we used to patch the hole left over from removing the clutch lever.

As noted and seen in the picture above, we removed the clutch lever. But then we had this open hole, and we didn't want mice to crawl in to the housing so we used epoxy and a roughly cut piece of aluminum scrap to cover the hole.
There are two pictures here. I don't have specifics of size because it's a random scrap piece that we just sort of shoved in the hole and then gooed up with epoxy to cover remaining gaps and hold it in place.
There are NO places you can scew or bolt anything too... and welding onto cast iron was beyond our abilities. Anyway, it actually works very well and it doesn't look bad at all.
Make sure to scrub and rub any old oil or dirt from around the edges so the epoxy can bond well. This is not a necessary step, but if you have mice that like to wander through your equipment like we seem to, it's something to think about.

View from OUTSIDE the clutch housing of the patch we made.

View of the hydraulic motor plate

Also NOT a necessary step (and only applies to those models of the Allis Chalmers that have a hydraulic pump) but we removed our hydraulic pump and replaced it with another plate and form-a-gasketed it on (oil leeks out of this area).

On our first Electric "G" tractor, we actually used the original hydraulic motor, and obviously (if you have one) you can too! But we found that it was slow... and so we replaced it with a 12 volt electric hydraulic motor and control from Northern Tool and equipment. We'll get to that part later in the instructions if you DO decide to do that.

We just left the hydraulic motor in place on the other tractor and so we didn't need to make any special plates, but on this tractor we thought we'd "reduce drag" and remove the motor all together. In retrospect, an unconnected hydraulic motor isn't really producing noticeable drag, so... I guess it was silly to do, but we were having fun. You can always do it later if you feel like it (or if you have a leaky hydraulic pump!)

Now you're ready to start putting things together! (Go back to the Home Page.)

(OPTIONAL) Custom-machined parts diagrams -for EXTREME DO-IT-YOURSELFers only!!!

In the first version of this so-called manual, I encouraged everyone to machine their own parts. Now I think that's not such a great idea. You could make the motor yourself too, but why? Unless you already own a big metal lathe (not the hobby sizes... the pieces we are making are too large), a really exact drill press, a metal band saw and have a lot of welding experience, you can't do it. You could hire a local machinist, but... if s/he's doing this for the first time, they will take more hours (and therefore charge you more money) than the company we had do the work for us (who I am NOT affiliated with in any way, and who I do NOT profit from in any way.)

What really made me change my mind and this second draft was when I recently did a second bolt-together of the machined stub, ring and clutch plate (this should only need to be done ONCE in any electric tractor's life-time. We have massively over-engineered this part of the project). It's not complicated, four screws and maybe 90 seconds of effort, BUT it needs to be aligned *perfectly*. Although we had machined the pieces at the shop, and put them together right there with a nifty little jig they made to force perfect alignments, I wanted to do it as though I had machined the parts myself in a home-shop, and then I could write about how easy it was to all of you!

Well... it LOOKED right, but without the jig, I was just a bit off! Problem is, you don't know it's wrong until you've put the whole thing together and start to drive off down the road. Then it goes "WHUMP-WHUMP-WHUMP". I had to take the *whole* thing apart and redo it from step 1, borrowing the jig. If you order the parts from Niekamp, they pre-bolt them together for you at the shop for free with the jig and you should NEVER have to deal with this problem!

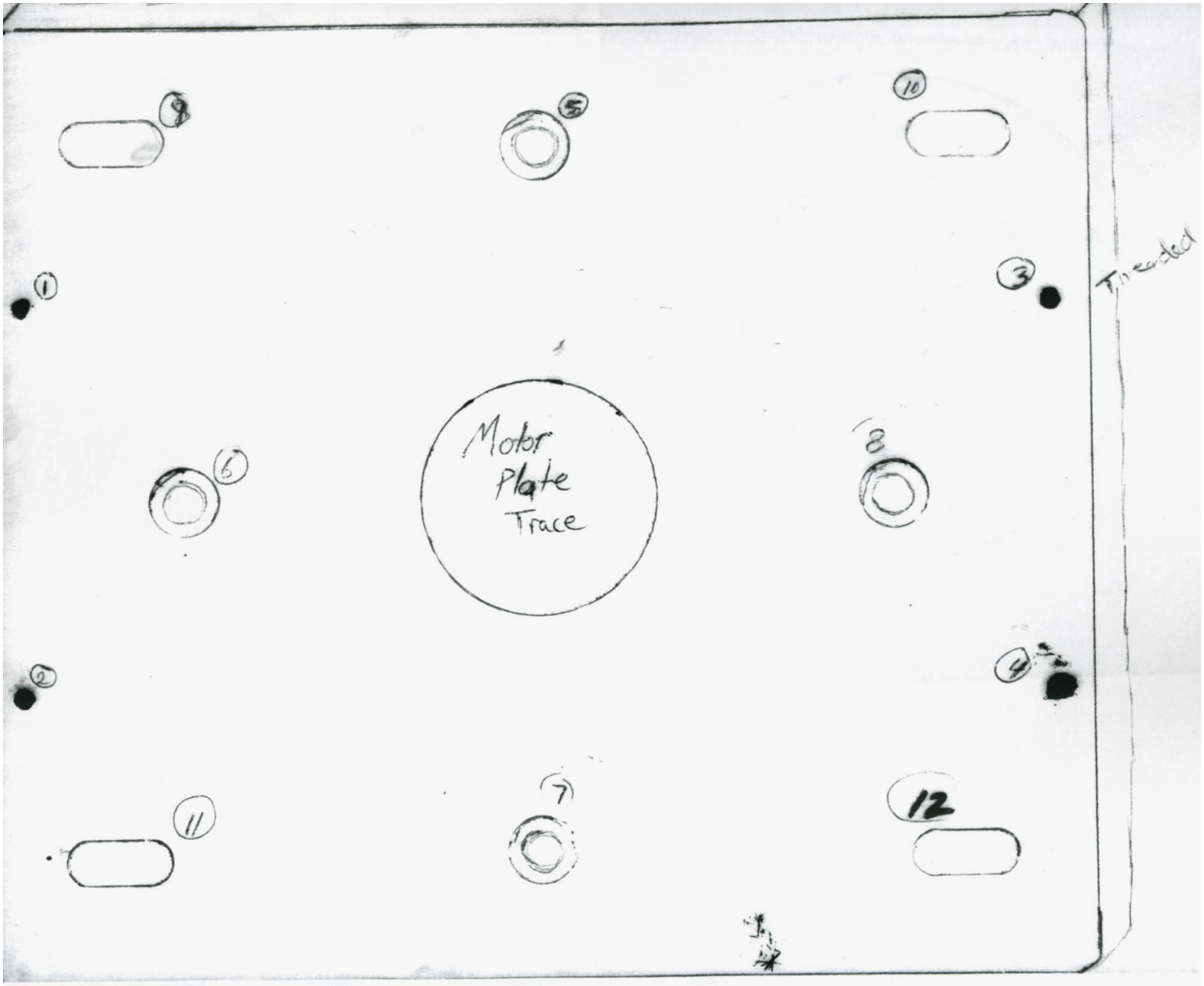
All this being said, if you REALLY want to do it yourself because you love your big lathe... (or maybe because you need to justify the purchase to your spouse) then go ahead and download the plate, stub and ring diagrams included here. While these are exact traces of what we are using (as well as CAD diagrams with precise measurements) I am frankly worried about things getting shifted or distorted in the scanning process.

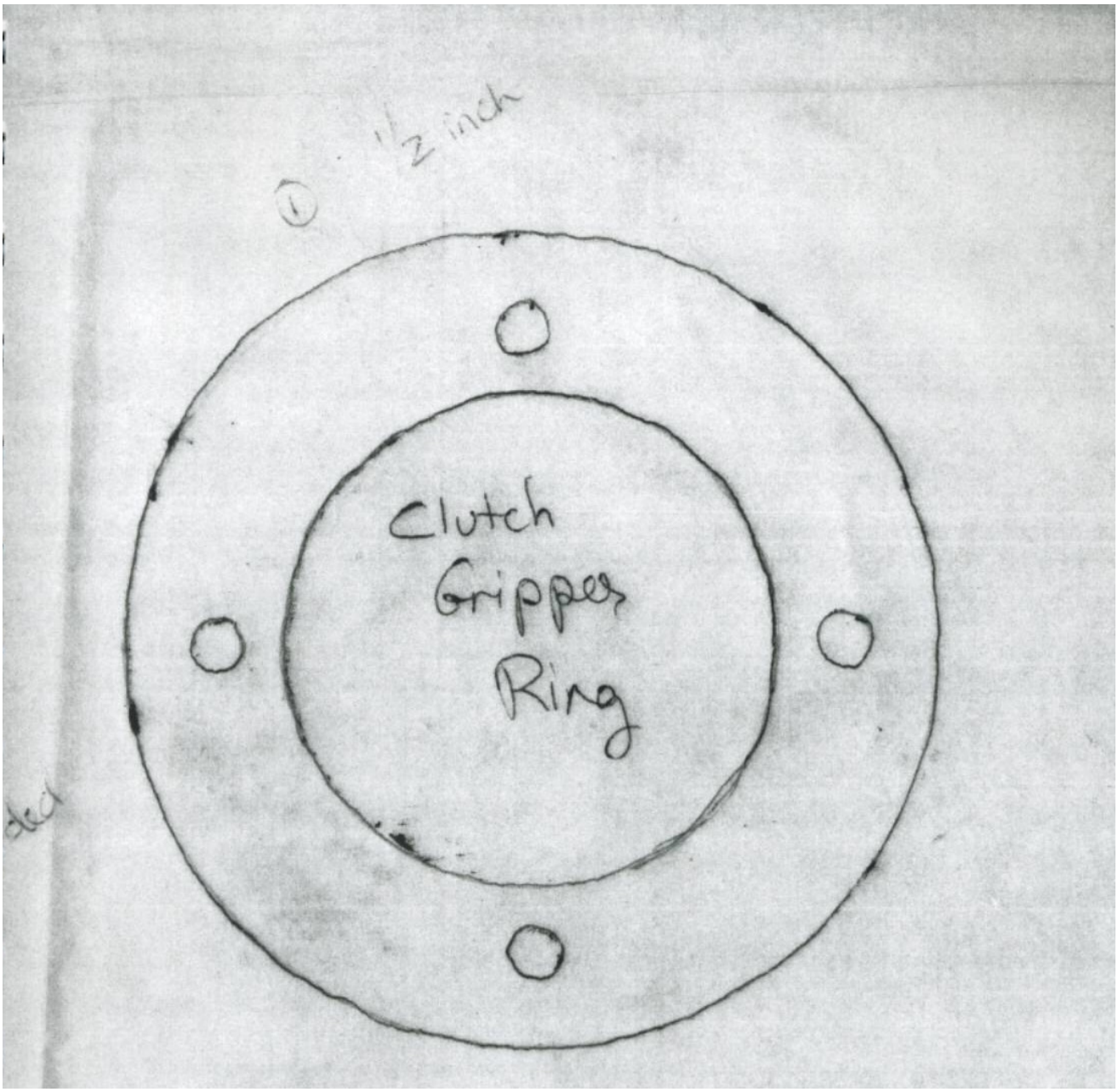
If you know enough to take this project on yourself, then you certainly know enough to re-check the measurements with your own tractor and the motor you buy and then you'll be fine. In the cases where you are just bolting your own created plates together, then just choose one to be the master and make everything else line up to that, and again, you'll be fine. If you just take these traces and CAD drawings out to the shop and start popping them out blindly without re-lining them up on your own tractor and components, then you may be sorry!

If you do decide to download these sheets and machine the parts yourself and have any questions or need clarification you CAN email me and I will respond, but **please** try to figure them out for yourself first, and be sure this is something you actually DO want to do yourself. Print out all four of these pages, and sit with them as you look at the tractor taken apart in front of you, with the motor and other components sitting next to it and things should start to make sense. It has only been a few months since I worked on this physically, but I have to admit it's taking ME some time to orient these things correctly. It's rather discouraging to be honest. I do remember, though, that when the parts themselves were in front of me, it was very obvious, and many of the component screw-holes we made using the components

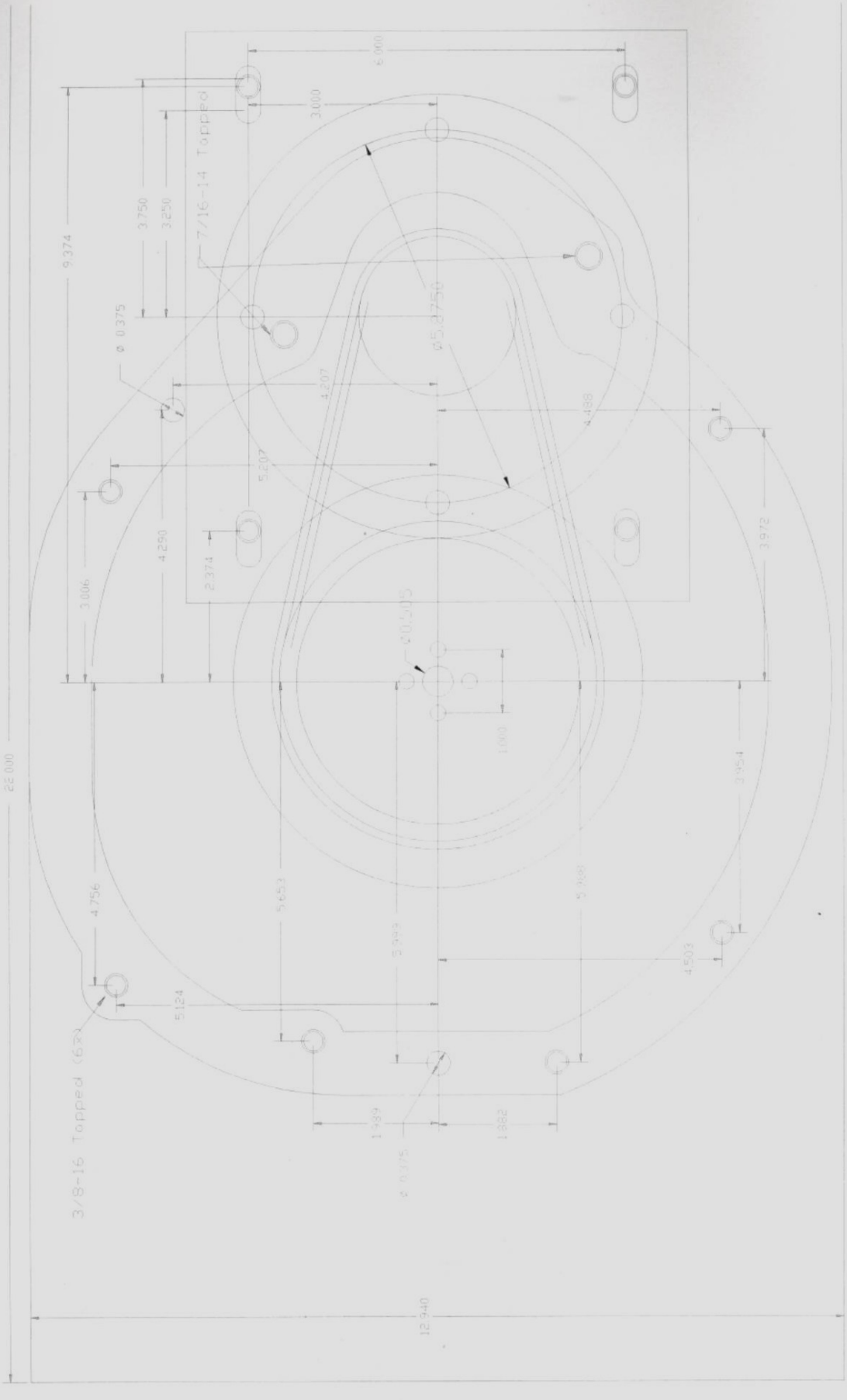
themselves as a guide.

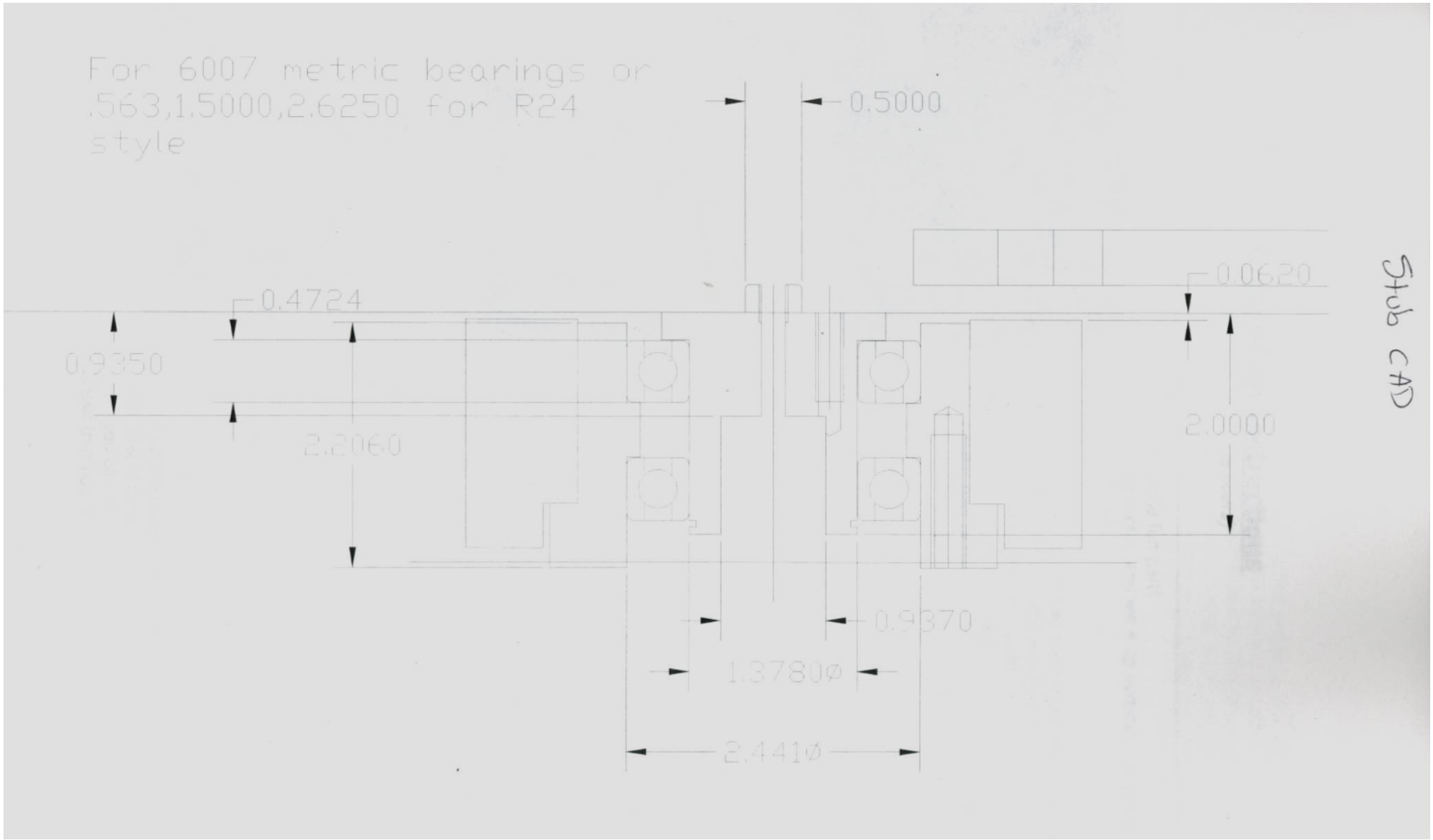
Don't forget this entire section is COMPLETELY OPTIONAL. Niekamp Tool Company now has several sets of all necessary parts pre-made in an efficient assembly line type process waiting at the shop to send out.


Motor
Plate
Trace
Threaded


1/2 inch
Clutch
Gripper
Ring

Bell Housing CAD




For 6007 metric bearings or
.563,1.5000,2.6250 for R24
style
0.5000
0.0620
0.4724
0.9350
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2.0000
0.9370
1.3780ø
2.441ø

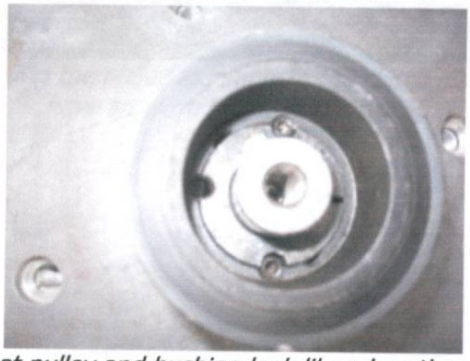
Stub CAD

Installation Instructions

(Estimated Time: 6-8 hours)

The electric motor, as it comes out of the box.

The smaller pulley fits on the motor shaft like this.



What pulley and bushing look like when they are screwed onto the motor shaft

Now, this is the fun part!
1) Take your motor, and set it up vertically, as in the picture to the left.

2) Set the smaller of the two plates your machinist made over the shaft. You are going to screw that plate on to the face of your motor, and your bolts can't stick up any, so you'll notice that you have tapered bolt holes... you want the WIDER part of the hole to face out, away from the motor, and the narrower part touching the motor. This way, when you put the bolts in, they will "hide" inside those holes and not interfere with later steps.

If your machinist did a good job, you will find that this plate fits very snugly around the raised area at the base of the spinnable silver shaft, and you will find this to be very satisfying.

3) Twist it around a bit and make sure that the four tapered holes in the plate line up with the four bolt holes on the face of the motor.

4) You should have a small rectangular piece of steel... that you can sort of tap into the groove on the silver spinning shaft of the motor. It should fit just perfectly and snuggly. It should have come with bushing that you ordered, that we are about to put on in step number 6 below... maybe they are in the same package. It's small!!

5) Slide the smaller of your two pulleys on. It says P16H150-110 8 on it. It has a narrower area inside with half screw holes and a wider open section. You want the NARROWER section with the half screw holes to be closer to the body of the motor. (see picture to the left).

6) Now slide on your bushing! It has "#1108 7/8 PRC L"printed on it. Keep the writing facing away from the body of the motor. It will only slide onto the shaft in one orientation because of the rectangular piece of steel you put on earlier. You'll probably have to tap it a bit to get it on.

7) Lift up the pulley sprocket so it's about 5/8" above the plate that is resting snugly on the motor. I just did this by eye, you can too... You have some room to play with. Push that bushing down by tapping it with a screwdriver

or whatever until it is nice and snug with that pulley... and the whole unit should, again, end up about 5/8" above the plate. Now put your screws in. They have an embedded hex head in them. You'll need a 1/8" allen key wrench to do it. Line it up so that your screws can go in any of three spots (there is only one way to do this). For some reason I only have two screws. I put them either side of the split in the bushing (see picture at left) and I tightened them decently snugly.

8) Now attach the motor plate to the motor using the four tapered hex head capped bolts (3/4 long x 3/8) that you bought. Put them on quite tightly!

Okay, now it's time to put the big pulley assembly together: **IMPO. NOTE: If you ordered the parts from Niekamp Tool Company, this step is ALREADY DONE FOR YOU at the shop! Just skip ahead to the next step!** ***The following instructions are ONLY for people who machined the plates and pieces themselves at home.***

Attaching the pulley assembly to the clutch disk (we have an extra ring in this picture).

You need to gather the larger pulley (it says P32H2002517 on it). And the large ring that looks like a washer, as well as the needle bearing (11/16th by 15/16ths by 3/4 (Jh1112)) and the bushing piece that your machinist made for you.

You also need to grab your old tractor's clutch plate! You know, the one I told you to save when you were taking the tractor apart!

1) First put together the bushing and bearing pieces into the bigger pulley.

2) Now attach the pulley assembly to the clutch disk using four screws and the big silver ring washer. In the picture to the left, note that we have an EXTRA thinner washer ring... your part won't need that, we've now implemented that piece into the bushing in the diagrams you'll give to your machinist (or order from Herman).

3) Okay, here's the big deal! That PTO Shaft protrusion in the center of your clutch disk has to be **PERFECTLY aligned in the center of the pulley assembly**! Herman made a little tool to get this perfect, and he'll send it to you for a few bucks+shipping (you have to send it back to him, though) I tried to fake it, and it didn't work.

Not to be obvious, since you can see it in the picture, but

do make sure that the stick-out portion of your clutch plate is sticking out AWAY from your pulley!

You will use four 1.5 inch long by 5/16 inch coarse threaded bolts to attach that outer ring to the bushing on the center of the pulley, making one solid unit. Put those on tight, because you don't want it to slip or move around over time.

Again, this step is ONLY for those who have machined these pieces themselves. If you ordered them Pre-made from Niekamp Tool Co., you do NOT NEED to bother with this step or ordering any jigs, etc. Just skip to the next place .

Big pulley screwed on to the center of the plate. Note it's screwed on to the side that has the nuts welded on to it, and the pulley is against the plate (with the zirc fitting sticking through the hole).

Another image of the big pulley screwed on to the center of the plate

Okay, now attach this new larger pulley assembly and clutch disk to CENTER of the larger plate. The picture at the left was taken just after I did it. Note that the pulley side of the unit you just made (or received in the box from Herman already screwed together) should fit against the plate. What you can't see from the picture, though it will be obvious in real life, is that there are four screw holes, and a place for the zirc grease fitting to slip through. It needs very little greasing and not so often.

Make sure that you attatch this assembly *to the side of the plate that has the nuts welded on to it!!!* That's not so obvious and easy to mess up, so be careful!

The four screws that hold the big pulley on, and the zirc fitting sticking through the center whole.

Setting the plate on the motor

Now we are ready to attach the motor to the big plate. This is a 2 person job. I recommend that you set the motor up on something, because, as you'll see, you have to attach some bolts in from underneath (the side that the motor is coming from), so sitting it up on a milk crate like we did here in these pictures, made it easier to get to.

I am missing a picture here, but it's easy... before you can attach the motor to the plate, you need to **first attach your SMALL plate to the motor.** This is very easy, the key element is that the bolts that you use to screw that plate on to the motor MUST fully fit within the recessed bolt-head-holes, so that that smaller plate can fit flush against the larger plate later.

Just to be overly explicit, when you look at your smaller plate, you will notice that the open holes are drilled out wider on one side than the other. You want those WIDER holes to be facing away from the motor, towards you. You have to use your hex-key bolts, because you won't be able to fit a wrench inside of that hole. Hopefully that makes sense!

Okay, NOW you can refer to the picture on the left. Once your smaller plae is tightly screwed on to the motor, you can set the larger plate on top of that! *Don't screw it on yet though!*

I am missing another picture here, but it's also very easy, you need to **slip the belt over the 2 pulleys.** First put it on the larger pulley, slipping it over the clutch plate, and THEN slip it over the smaller pulley.

NOW you can attach your screws! They go in from

The four screws holding the motor on to the main plate. The holes are much larger than the screws so you can move the motor around.

"underneath", that is, from side of the plate that the motor is on. That's why I wanted you to set the motor up on a milk crate. Those bolts screw in to the four welded-on nuts on the big plate. Just put them on loosely for now, and *Don't forget the washers.*

As you can kind of make out in the bottom picture to the left, the holes that these bolts go into are much larger than the bolts themselves, that's o we can move the motor around and in that way tighten the belt! So, go ahead and slide the motor around until you get that belt pretty snug on it's teeth. Don't overtighten it, you aren't trying to tune a guitar string, it should just be snug. NOW tighten those bolts on so that they won't let the motor slip and loosen the belt!

Okay, now we attach that plate/motor assembly to the back of the tractor. You are almost at the point of having a working tractor!

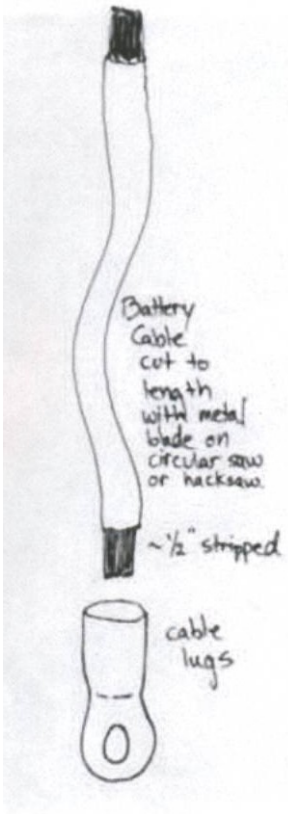
As you can see from the picture on the left, We set the milk crate down under where the motor was going to go because this assmebly is heavy. It took all three of us to set it on, and it took several tries, because you sort of have to "jimmy" it on so that your clutch plate fits back on to its old familiar place slipped over the sprocket heading in to the transmission.

Have the bolts handy, so as soon as you've got it "sorta" on, you can use the bolts to pull the plate in the rest of the way. Having done this MANY times now, I can tell you this is the ONLY way to get such a heavy plate on!

Now you are ready for the electrical components!

First, let's make the all the cables you will need. Find the cable and cable ends (also called cable lugs) in the box from Electric Vehicles of America. You have to cut the cable to the right size, stip off about 1/2" of insulation from either side (enough to fit in the cable ends) and then crimp the cable ends down.

First, cut the cable. You can use a hack saw, or... I put the cable in a vice, and attached a metal disk-blade to my circular saw. That made very short work of the cutting process.



-Make three (3) pieces of cable that are exactly 2'2" (two feet-two inches) long.
-Make two(2) more pieces of cable exactly 1'10.5" (one foot-ten and a half inches) long.
-Make one (1) piece of cable 1'5.5" (one foot-five and a half inches) long.

-Make two (2) super-short pieces of cable... Just big enough to fit terminal ends on either side.

Now, strip the ends about 1/2 an inch (check the length with the cable lugs you received, there are different types, and you don't want to have extra metal showing.

Permanently fix the cable lugs on one side of each of your wires. Attach the other side loosely. Afix the cables to the tractor as noted below. Note the alignment of the cable lugs, and THEN smash them down in that same alignment. Does that make sense? I hope so. It takes a bit longer, but if you do it this way, your cables won't be twisted at all, reducing torque on the terminals of the components and batteries.

You can buy a cheap little tool to correctly and permanently smash the cable ends onto the cables. I hope I don't get in trouble for saying that I just smashed the cable ends flat with a hammer the first time I did this, and... they are working great. It is essential that the contact between the cable and the ends is EXCELLENT, not just "good". If you do a bad job, do it again -even if you have to go to the auto shop and buy more cable and ends. There are a LOT of amps flowing through these wires, so a loose connection is going to heat up and will very possibly melt... Certainly it will pop and hiss and your tractor will not run very smoothly.

All of this electrical work is very simple, but must be done perfectly neatly and securely and it should

be checked often and repeatedly throughout the season because your tractor is going to be bouncing and jiggling and things do loosen up! It takes less that 60 seconds to check the obvious connections for tightness. We made a sign for our tractor that we used to leave on the seat to remind us. It saves trouble (not serious trouble, but trouble and confusion nonetheless) down the road.

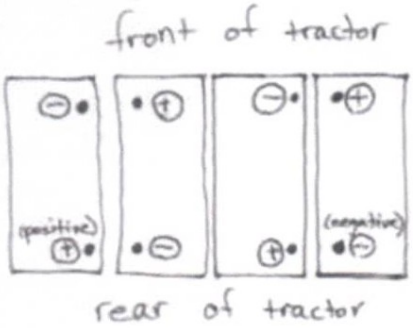
I'm going to repeat that above advice, but I wanted it to be playing in everyone's head as they are building.

Okay, set your cables aside, and let's bolt more components onto your tractor.

Battery Platform (not fully assembled)

Okay, first let's put the batteries on. Most of you will have purchased your machined parts from Niekamp Tool Company, and they nowinclude a battery box platform (without the plywood). All that remains for you to do is cut a piece of plywood for the batteries to sit on that fits into the welded metal frame they made. You can see in the diagram to the left where the battery platform bolts onto the tractor.

To the left, you can see the plywood battery platform we cut out (one battery has been removed, and not all cables are afixed.) Note that we drilled two holes to feed the cables through to the motor and controller. You don't have to do this, but you should. It makes it so much neater (though I have to admit this picture isn't very flattering!)



Once the plywood platform is on, set the four 12 volt batteries on the platform as shown in the configuration diagram to the left. The platform should be big enough to hold 6 eight volt batteries as well.

If you machined your own parts, then obviously you will need to make a little platform for the batteries to sit on yourself. This is VERY easy to do.

Take a look at the picture to the left. It shows the existing spots you can use to mount your battery box. You are looking at the tractor from underneath the battery box we built.

The left hand side of the picture is the front of the tractor, and that left arrow is pointing to what used to be the mount for your old gas tank. The right hand arrow is pointing towards the two bolt holes you would use to

Arrange the batteries on the platform as shown here.

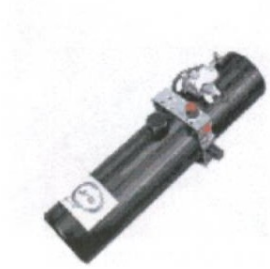
Attachment points for battery platforms.

attach a rear implement. There are plenty of other ways you could configure the battery box, this is just one way.

You can tell we welded angle supports and the square frame to hold the batteries, but for our first prototype tractor we bought angle steel from Home Depot that had lots of pre-stamped holes in it. We cut four pieces down to size, attached them to the four connection points, bolted on another four pieces to make an upper frame, and set a plywood box on top of that, and it held up for three years with relatively few problems.

For everyone:
The batteries weigh 80lbs each. In the years that we have been running this, we have NEVER affixed the batteries to the box, or even attached the box to the metal frame. In the version you are seeing here, we don't even USE a box, just a flat piece of plywood, and it hasn't caused us any trouble. 320 lbs of lead just don't move around much! We built a wooden cover box to go over these batteries just to protect them from the elements, but recently someone suggested that we just put an appropriately sized rubbermade tub over the batteries... that would be even easier.

Optional Electric Hydraulic Motor Installation
This is an optional step, but I'm glad we did it. For the first year, we used the existing hydraulics on the tractor. Not everyone's "G" tractor even HAS hydraulics. Some of you have big long levers to raise and lower your front implements, and they work great for you.



We had a hydraulic motor on our tractor, and although the electric conversion didn't impact our existing hydraulic pump, it was really slow and annoying (just because it was so old, I think). So we purchased a **12 volt hydraulic pump with an attached 3-way joystick switch** , (the cheapest, smallest one,) from the Northern Tool catalogue (www.northerntool.com). They don't call it a hydraulic pump, they call it a "12 Volt Power Unit", and I'm sure lots of places on the internet sell them.

We removed the original old battery box from the right hand side of the tractor (you know, the battery that used to start your gasoline engine). We screwed a square piece of 2x8 onto the mounting holes for the battery box and then we bolted the new electric Northern Tools hydraulic pump onto that piece of wood. (You can't bolt it directly to the tractor because the mounting holes for the original "G" battery box don't line up with the mounting holes on the hydraulic pump. Using the wood makes it easy and

you don't have to weld anything onto the tractor!)

This placement of the pump (with the attached joystick on top of the pump) means our hydraulic controls are close and handy right next to your seat! It cost under $300, and the electrical installation is a no-brainer (just two wires running to a battery in the back).

This is an easy thing to add on in the future if you feel it's worthwhile. We do like ours. One important point if you DO decide to do this, is that the hydraulic motor is a 12 Volt component! So... you would NOT want to run it off all 4 batteries (putting out 48 volts) or you will burn it out!

We just chose one of our four batteries and run it off that one battery. Of course that is not how you SHOULD do it, that is a "Farmer Hack" but we find that it doesn't matter at all. Yes, that battery must be running down a little faster than the others, but the truth is that we only operate the hydraulic pump for literally 1 second bursts at a time, and then a very finite number of those 1 second bursts in a given day, so... I haven't seen that it is noticeably exausting the battery. I do change the battery that it's running off of a few times a season, though....

If you want to do it right, Electric Vehicles of America sells the 48volt-12volt converters you need. I'll write about this again at the end of this installation section when we talk about powering the Contactor.

There are 3 of these spacers to keep the controller up off the plate. If you purchase a different controller, it's easy to install it on a piece of plywood, and then attach the plywood to the plate, but you'll still have to use the three spacers to keep the plywood spaced off the plate (or you'll interfere with the pulley screw underneath).

OKAY! There are only three more pieces to bolt on to the tractor! Let's start with the most complicated, **the Controller.**

You may not have the same controller we list in the "Parts Ordered" page. They keep improving them, and prices keep changing up and down... don't worry about it (just make sure you did get the weatherproof version!). The basic configuration of what wires go where is consistent and well labelled on the two controllers we've seen. If you don't have the same labels, you should read the directions. I have to admit I couldn't understand the directions on our controller, so Bob at EVA had to interpret them for me. Now it works great and I understand why.

If you have a different controller than I list here, you may also find the mounting holes don't match up with the mounting holes we've given you on that back motor plate! Don't panic! It will just take a LITTLE bit of creativity on

The installed controller. Ignore the wiring for now.

your part...

No matter which controller you have, as you face the rear of the tractor, the controller mounts on the LEFT hand side (see picture at left).

You will see there are three holes in your plate. Those holes are threaded so you can actually screw a bolt into them. Mount your controller so the terminal ends are facing UP. If you have our exact controller, you will see there are four mounting holes on the sides of the controller. We are only going to use three of them. We are also going to use the three little spacers (see picture at left). You need the spacers because the pulley screws are underneath the controller!

Now, in case you don't have our listed controller, see if the holes line up anyway. Maybe you will be lucky! If they don't line up, can you drill new holes through the aluminum plate on the bottom of the controller? (Obviously WITHOUT breaking through the case). If you can, then great. Otherwise, take a piece of plywood and drill holes through that to line up with the holes on the plate of your tractor. Now drill new holes so you can bolt (not screw) the controller to that piece of plywood! Easy!! You will need to use the spacers between the plywood and the metal plate, but you DON'T need spacers between the controller and the plywood.

Now attach the **"Albright Contactor".**


Installing the Contactor

Why do they call this a "Contactor" instead of a "Relay". I don't know. It is just a big Relay switch. By applying 12 volts of power to the relay, you turn the switch "ON" and the full 48 volts can flow to your motor.

You may ask, (like I did) "Why do I need a Contactor? Why can't I just turn a normal, manual switch on and off?" Or, you may be cheap (like I was) and say, "Oh... I'll just turn the tractor on and off by touching the wires together. What's the big deal? And I'll save $55!"

I must admit, it's been very exciting to learn *why* this is a bad idea. I'll spare you the science, but basically, because this is a low voltage DC system, the CURRENT flowing through these wires is very high! (That's why we need to use such thick wires.) If you tried to use a normal switch to turn this on and off, or if you just tried manually connecting and disconnecting the wires where they are supposed to go when you wanted the tractor to start up, there would be a blinding flash of light, a puff of smoke,

and metal would literally VAPORIZE before your eyes! WOW! Could this be on-farm proof of E=MC2? I think so!!! When you are able to see again, call all your friends and tell them you are a genius.

We don't do these sorts of fun experiments anymore, but you can tell that we DID at one time because there are lots of chunks of metal missing from the ends of our cables. Our original set of batteries (which were destroyed) show where we melted through the plastic. What expensive fun we had in those early days. If only we were rich enough to afford it.

You can save yourself some money in batteries and wire by just imagining the fun we had and using an Albright Contactor from the beginning. Hopefully you got the "all weather" version. If you didn't (like us), you can make an "all weather" case by dropping your contactor into a capped piece of pvc pipe and caulking around the hole where the wires go in and out! Then, where your mind clears from all the toxic PVC fumes, you can still call your friends and tell them you are a genius.

The Contactor screws in to threaded holes that are supposed to be drilled near the center of that back Motor Plate, in between the controller and the motor (See picture to the left). Don't worry if you ended up getting a DIFFERENT contactor than we did. The best thing to do though would be to drill and tap new bolt holes in that back metal plate in configuration with the holes on the Contactor you purchased. Don't attach this very tightly, because you will need to futz with it a little bit when you attach the wires as you'll see in a few minutes.

Here is how we screwed the "Potbox" into the metal frame supporting the battery box.

Now attach the **Speed Controller (Officially called the PB-6 Potbox).**

This item attaches to your tractor so easily that you will wonder if the AC-"G" folks back in 1947 were planning for these new millenium electric conversions. First, if you ordered the machine parts already made, you have it REALLY easy. The Potbox just screws right in to the bottom of the battery platform -right into the metal. If you made your own platform, just drill and tap two holes so that you can screw this item roughly in line with the existng throttle control on your tractor (the lever on the left hand side, under your seat.).

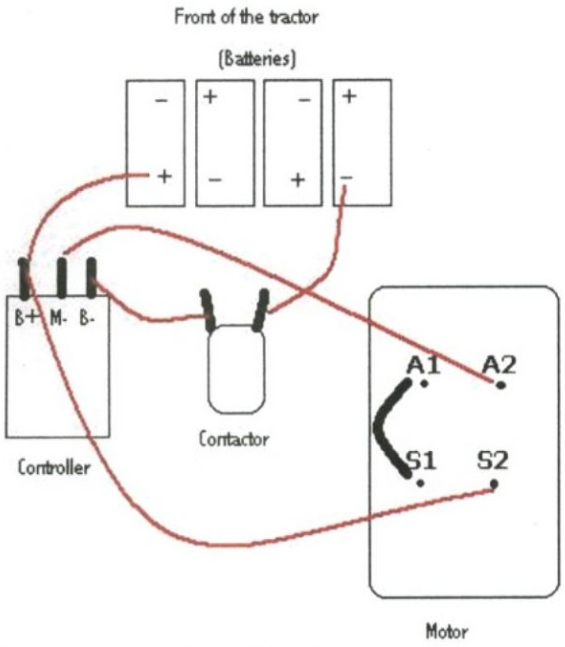
Niekamp Tool company will send you a shiny metal rod with a hole in it to attach the Potbox to your existing under-the-seat throttle control. If you machined things yourself, you can just use the rod from the original

This is how the metal rod screws into the original throttle on the tractor. Although we used a new shiny metal rod here, you could just as easily use the original throttle rod once it is bent straight and cut a little smaller.

tractor! Bend it straight(er), cut off the excess and wire it on to the end of the PotBox switch.

Try it out, and make sure you connected it the right way. When you push FORWARD on the lever under your seat, it should pull the Potbox lever forward, (allowing you to drive forward at increasing speeds) When you push backwards, it should allow the Potbox lever to spring back to it's original resting place, bringing you to an easy stop.

It's that easy! Now let's connect the wires!



Wiring Diagram for all big wires.
Note the the placement and labelling of terminals on your controller and motor may be DIFFERENT than what you see here. Look and follow the labels as written on your components, rather than just automatically attaching the positive battery terminal to the far left Controller terminal (for example)!! Also, note the black wire between A1 and S1 on the motor... see the description to the right.

Final Wiring
At this stage you are just a few minutes away from driving around the yard on your electric tractor.

Note of caution
I need to start by repeating what I wrote above. This is going to feel like such an easy job, but establishing good strong connections, and no loose wires, is essential to safe and happy electric tractor operation. Check your connections often (like every day before you take off) to make sure they haven't loosened up.

Installing shrink tubing
Bob at Electric Vehicles of America is now sending out shrink tubes to go over the lug ends of your wires. You could also use electrical tape. The point is, you want to minimize the open surface area of your wires. The shrink tubing is a breeze, you just slide it on, and then heat it up by quickly waving a propane torch under it (not so it melts, just enough heat that it starts shrinking.) We didn't have this when we built our tractor so I don't have a picture, but it seems like a good idea. Do this step after you have figured the alignment of each of the wires and have smashed down the loose lug side.

Below are more detailed written instructions of exactly what you are hooking up and where. To the left is a diagram. Please do read the descriptions below.

#1: Take a 1'10" piece of cable. With a permanent marker write **Batt +** on one side and **B+** on the other

side. Facing the back of the tractor, one side goes on the left-most POSITIVE battery terminal. The cable fits through the hole you probably drilled in the bottom of your battery platform and attaches to the big terminal marked **B+** on your controller. When you have the alignments right, smash the battery lug all the way down on the wire (obviously remove the cable from the tractor for this step!) and shrink wrap or tape the unnecessarily exposed parts of the wire and go ahead and tighten it down on top of the battery, but NOT on the B+ terminal of the controller because we are about to attach another wire there.

#2: Attach a 2'2" cable from **B+** on your controller to **S2** on your motor. Once you have the alignment of the second cable lug correct, remove it, smash it down, shrink wrap or tape the ends and tighten back on correctly on both sides.

#3: Attach a 2'2" cable from **M-** on your controller to **A2** on your motor. Once you have the alignment of this third cable's lug correct, remove it, smash it down, shrink wrap or tape the ends and tighten both sides.

#4: Attach a 1'10" cable from **B-** on your controller to either large terminal ends of your **Albright Contactor**. Once you have the alignment of this third cable's lug correct, remove it, smash it down, shrink wrap or tape the ends and tighten both sides.

#5: Attach a 2'2" cable from the open terminal on your **Albright Contactor** to the **Negative terminal of the right-most battery**. Once you have the alignment of this third cable's lug correct, remove it, smash it down, shrink wrap or tape the ends and tighten both sides.

#6: Note the black wire in the diagram to the left between A1 and S1 on the actual motor. They must be connected together, but on our motor they are so close that we couldn't actually make a cable small enough to fit! While you could do multiple wraps of exposed copper wire, bolted on, we actually cut out a piece of 1/8th inch copper, notched it, and then bolted that between the two terminals. It looks very neat.

Now it's time to connect your batteries to each other. Because the batteries are all on one plane, alignment of your cable ends isn't going to be a problem. So you can go ahead and smash down all the remaining cable ends and shrink wrap (or tape) them up to protect the

unnecessarily exposed parts.

#7: Starting with the left most battery, attach a super-short cable from the (open) negative terminal to the positive terminal of the battery to the right.

#7: Now attach a 1'5" cable from the open negative terminal of that second battery to the positive terminal of the the 3rd battery to the right.

#8: Now attach a super short cable from the open positive terminal of that third battery to the negative terminal of that last battery.

That's it! You're done, and you shouldn't have any more big cables left!

Let's attach the small wires coming off your Potbox

Start with the grey wires coming off your **Potbox**. Crimp "Quick Disconnect" terminals (from your local auto-parts store or Radio Shack) of the size appropriate to fit onto the small terminal ends of your **Controller**.

Looking more closely at those small metal contact points on your **controller** . The terminals are numbered on both our Alltrax controller and our earlier (unknown brand) controller. Attach the small **black wire** from your Potbox to terminal end #3. Then attach the small **white wire** from your Potbox to terminal #2.

Now take a short piece of wire and crimp on a quick-disconnect terminal to one side. Attach the other side to the big B+ terminal (or directly to the positive lead on your battery if there is more space for that) and slide the quick-disconnect onto the small terminal marked #1. When adding this small wire, it's essential that you don't diminish the contact between the battery cable end and the controller (or battery).

NOTE: Obviously, you should read the instructions for your own controller. I am telling you how we installed two different companies' controllers, but I don't know what other controllers look like. I've written the details here because it is LIKELY you will end up with our same Controller componentry. Even if you don't, hopefully it will help you to understand whatever you do purchase, because this was a very complicated step for me.

What I've written here is the easiest way to approach the pot-box/controller wiring, but you may want to read

through your controller manual (even if you have the same ones we have) to see if you'd like to do it another way.

For example, we don't actually run positive power from our battery directly to the #1 terminal of our controller as I've written above. Instead, we run the power through the Potbox. If you look more closely at your potbox, you will see that it also has some small terminal ends sticking out. I hesitate to give exact details here because (again) I worry that your components may not be exactly the same as ours, but you can read the instructions (or use the resistance/continuity tester of your Voltmeter) to learn which two of those leads give you a simple "ON-OFF" switch. When the Potbox is in the fully relaxed position, they are off and discontinuous. If you move the lever even the slightest bit forward, they become "connected" and the switch is "ON".

We connect it that way so that even if power to the tractor is left on, unless the Potbox is activated (by pushing the throttle lever under your tractor seat) no power will run to the controller. It's not necessary, but nice to engage this feature.

The last item is the **On-Off switch** . You should read the instructions for your **Contactor**, because, as with the Controller, I don't have a lot of experience with different companies' contactors!

The basic concept is simple though and will be consistent with any Contactor you buy. It's just a big relay switch, so you need to run 12 Volts of power to make the switch "close" and allow the massive amperage (and full 48 volts) to power your motor.

You can mount the on-off switch wherever is convenient for you. I'll leave instructions for that out... I'm embarassed to say that ours is still just hanging off the back of our batteries from it's wires! I really meant to make it nice and pretty, but... in all these years, I never have on either of the tractors.

Make sure your switch is in the "off" position and run a piece of the insulated 14 gauge automotive wire from the the positive terminal of one of your batteries to the on/off switch. Then run a piece of insulated 14 gauge automotive wire from the on/off switch to the small positive terminal (or it may be a wire -probably a RED wire) of your contactor.

Now run a piece of insulated 14 gauge automotive wire from the negative terminal **of that same battery** straight to the negative terminal (again, it may be wire - probably a BLACK wire) of your Contactor [remember, the Contactor runs on only 12 volts of power. If you run it on the full 48 volts of power you'll burn it out!]

Note: As with how we powered the 12volt hydraulic motor, this is the "farm" way of approaching this installation. Officially, you should have a DC converter to bring your 48 volts to 12 volts, and that should be charging a separate (fifth) 12 volt battery, and then that fifth battery is what should be powering the Contactor (and Hydraulic Pump, and any other 12 volt components you may add to your tractor... like lights.)I don't do that because I am cheap and becuase the Contactor uses so little power that I haven't observed that it is draining the one battery it is connected to more than the others. Still, I wanted to note that what I have done isn't exactly "by the book."

OKAY! You should be able to turn the switch on and drive away! If this is the first time you are running the tractor, make sure your batteries are fully charged before you really head out into the fields!

Good Luck! And please do send an email to let me know how it's working out for you and how these instructions can be improved!

APPENDIX I:
Notes on Solar Panel Charging

Overview
We added solar panels to charge the tractor. This is a decision you really need to think about before you do it because it is expensive. Ideologically it feels nice to have a tractor running completely free of fossil fuels. In addition, it is a long drive for us from our back growing fields up to the barn and power, so being able to leave the electric tractors out the back field to be fully recharged by the sun actually saves us 30 minutes a day per tractor, which... over the course of a season is tremendous.

We are much more likely now to just throw in one bed of carrots when we used to bundle things to save driving time. Perhaps more importantly, we are more likely to tractor-cultivate at the right time -we used to bundle cultivations like we bundled seedings... and then if it rained we missed our chance entirely.

So these are some good points, but... the "bottom line" problem in that we calculate that we spent under $12 last year charging BOTH our electric tractors for the entire season. $12 in electricity is not a lot. From THAT perspective, it makes the solar panels a pretty silly addition.

Of course as Farmers, we've learned to look very creatively at our bottom line problems. When you look at the cost of solar panels AND the conversion, the electric "G" is still far cheaper than a new cultivating tractor. It also just "feels" SO COOL to not have to plug the tractors in. We also have a converter (which we haven't used yet) that allows us to power the whole house (and our walk-in cooler) off the tractor batteries, which were charged off the sun, so... that's literally cool . And from a marketing perspective, saying we run the farm on electric tractors is good, but getting to say we run it on SOLAR electric tractors... well, that just takes the farm right over the top!

Finally, in trying to justify the solar panels to my much more practical wife, I must return to the labor saving factor. We value our personal farm-labor time at $20/hour. In the years we are planting in the back fields, we will save over $800/year in our own labor-hours! And maybe MORE if you consider that sometimes we try to do things by hand that should and could have been done by the electric G's if they were closer-to-hand. Doesn't that sound nice? Kate doesn't completely buy this argument, because she points out that we've never actually MADE $20/hour working on the farm, but... it's the best I can come up with for now and anyway she

DID let me buy the solar panels.

Cost and Components

We budgeted $1300 for this and we ended up spending at least $2200 (I stopped counting at that point), but it seems the prices on these components are changing rapidly. Even the components themselves are changing so rapidly that you may not be able to order what we ordered. That is why my description is so general. You just need to find components that do the job listed here, rather than wasting your time trying to find the exact components we used.

A GREAT website to get an idea of prices is www.mrsolar.com. We didn't use them, but they have terrific free technical support (which I did use) and their prices look really good now that I've done more research. We hired a local solar expert here in New Paltz, Dawn Hein, to order the parts and worked with her to set them up on pallets so they can be easily moved to the "active field."

There are plenty of different ways to go about doing this... more and less complicated. You or whoever advises you may suggest a different way. Obviously I like the way we did it, but it is NOT the only way this could be approached.

Our system consists of 4 panels, hooked together to create 48 volts of output. You can order ANY panels you want as long as you end up with a total of 48 (nominal) volts of output because we are working with a 48 volt battery system to run the tractors.

We didn't NEED to buy 4 panels... we could have bought two panels and it just would have taken longer to charge the tractors. Do whatever you can afford. You can also add more later. But of course, don't forget that you must end up with 48 volts coming out the back end of your charge-controller.

[Not to be overly complicated, but what I just wrote isn't actually true. You could get one 12 volt panel, and hook the charging wires of your four 12 volt batteries in parallel to a 12 volt charge controller coming off that 12 volt panel. There are benefits and problems associated with this approach too... but if I go into them, I will never finish this section of the manual. So you need to decide what you want to spend, and then do a lot of research or find an expert to help you, or better yet, do what I did and convince your wife that if you just double the budget it will make your life a heck of a lot easier.

Okay, let's talk about the 48 volt charge controller we bought. It was under $100. Great Bargain! All it does is to decide how much power will ACTUALLY go into the batteries. a nominal 48 volt solar panel system may actually put out a LOT more than 48 volts (or a lot less)... So... you need a controller to temper and adjust it. Also, the batteries may be charged at different voltages at different times. This device takes care of all that, and they keep coming up with better and better versions of these devices.

We also purchased a fused D/C "on-off" switch. It was ridiculously expensive for what it does. We could have bought an A/C version for 1/4 the cost at Home Depot, but it would have sparked and melted if we had tried it out on a sunny day. You don't need to know why I know that. Anyway, this expensive one is rated to handle many times the amperage that we are putting out, but... we are safe and the tractor is safe and nothing is catching on fire... and metal isn't melting... and so we bought it.

You can purchase frames to hold the solar panels, or you can make them yourself. We made a simple triangle out of angle-aluminum and bolted it to two pallets. You can see it in the picture. What you make or what you buy will depend entirely on what panels (and how many) you end up purchasing.

Why Not Bolt the Panels to the top of the Tractor?
This seemed like such a good idea. It would shield us from the sun, and we talked to the panel experts and they said that the panels should be able to hold up to the jolting and bouncing of the tractor. They are so expensive, that it sort of scared me though.

But that's not why we didn't end up bolting them to the top of the tractor.

They are also pretty heavy, and we like our tractor to be light to minimize compaction. But... that's not why we didn't bolt the panels to the tractor either.

We didn't bolt the panels to the top of the tractor because we wanted both sets of panels to charge our two tractors. We are often using one or the other tractor. So... we could leave one tractor charging while we used the other. Also, we wanted the solar panels to "condition" the batteries during the winter -and we didn't want to leave the tractors themselves outside, just the panels.

Okay, finally, the biggest reason we didn't bolt the panels to the top of the tractor is because I like to drive fast, and they are heavy enough, that the framework required to safely keep them from falling on one's head is not a joke. I either had to committ to slowing down OR do a lot of really complicated engineering and building that I just didn't want to take on. Plus, we have a pallet lifter for the back of our tractor, so it was a no-brainer to just use that to move the panels to where-ever they will be most useful for the next few weeks, and then we can go ripping through the fields safely unencumbered. Judge me if you want, but that's the whole truth.

Appendix II:
Battery Care

We destroyed our first batteries even though many people warned us that we WOULD destroy our first set of batteries. I'm hoping to save you the same trouble.

A conservative life-span for lead-acid batteries in an electric car is 3 years. But there are folks running alternative vehicles like our tractor that have been using the same batteries for over 10 years. A car is generally run more often and regularly and to a much greater extent of discharge. Altough we use our tractors often, we are generally only going a mile or so at a time then re-charging them, so they don't get permanently exhausted as fast.

The most important statistic for you to know is that 85% of dead/old batteries in Electric Vehicles are only dead because of excessive sulfation NOT because they really "need" to be dead.

I am copying below information from www.uuhome.de/willima.darden/carfaq16.html on desulfating batteries, but the most important thing for you to know is that you should keepsulfation from happening rather than trying to fix it and "Recover" your batteries. We let ours go too long and were NOT able to recover them that first time. Since then, we have had no problems.

How do I prevent permanent sulfation?
(From http://www.uuhome.de/william.darden/carfaq16.htm)

The best way to prevent sulfation is to keep a lead-acid battery fully charged because lead sulfate does not form. This can be accomplished three ways. The best solution is to use a charger that is capable of delivering a continuous "float" charge at the battery manufacturer's recommended float or maintenance voltage for a fully charged battery. 12-volt batteries, depending on the battery type, usually have fixed float voltages between 13.2 VDC and 13.8 VDC, measured at 80° F (26.7° C) with an accurate (.5% or better) digital voltmeter. Based on the battery type you are using, charging can best be accomplished with a microprocessor controlled, three stage (for AGM or Gel Cell batteries) or four stage (for wet batteries) "smart" charger or by voltage-regulated float charger to "float" or maintain fully a charged battery. A cheap, unregulated "trickle" charger or manual two stage charger can overcharge a battery and destroy it.

A second and less desirable method is to periodically recharge the battery when the State-of-Charge drops to 80% or below. Maintaining a high State-of-Charge (SoC) tends to prevent irreversible sulfation. The recharge frequency is dependent on the parasitic load, temperature, the battery's condition, and plate formulation (battery type). Temperature matters! Lower temperatures slow down electro chemical reactions and higher temperatures speed them up. A battery stored at 95° F (35° C) will self-discharge twice as fast than one stored at 75° F (23.9° C).

A third technique is to use a regulated solar panel or wind or water generator designed to float charge the battery. This is a popular solution when AC power is unavailable for charging.

How do I recover sulfated batteries?
(From http://www.uuhome.de/william.darden/carfaq16.htm)

Here are three methods to try to recover permanently sulfated batteries:

Light Sulfation
Check the electrolyte levels and apply a constant current at 2% of the battery's RC or 1% of the AH capacity rating for 48 to 120 hours at 14.4 VDC or more, depending on the electrolyte temperature and capacity of the

battery. Cycle (discharge to 50% and recharge) the battery a couple of times and test its capacity. You might have to increase the voltage in order to break down the hard lead sulfate crystals. If the battery gets above 125° F (51.7° C) then stop charging and allow the battery to cool down before continuing.

Heavy Sulfation

Replace the old electrolyte with distilled, deionized or demineralized water, let stand for one hour, apply a constant current at four amps at 13.8 VDC until there is no additional rise in specific gravity, remove the electrolyte, wash the sediment out, replace with fresh electrolyte (battery acid), and recharge. If the specific gravity exceeds 1.300, then remove the new electrolyte, wash the sediment out, and start over from the beginning with distilled water. You might have to increase the voltage in order to break down the hard lead sulfate crystals. If the battery gets above 125° F (51.7° C) then stop charging and allow the battery to cool down before continuing. Cycle (discharge to 50% and recharge) the battery a couple of times and test capacity. The sulfate crystals are more soluble in water than in electrolyte. As these crystals are dissolved, the sulfate is converted back into sulfuric acid and the specific gravity rises. This procedure will only work with some batteries.

Desulfators

Use a desulfator also known as a pulse charger. A list of some of the desulfator or pulse charger manufacturers is available on the Battery References Links List at http://www.batteryfaq.org.

Despite manufacturer's claims, some battery experts feel that desulfators and pulse chargers do not work any better at removing permanent sulfation than do constant voltage chargers.

APPENDIX III: **NOTES DISCLAIMERS THOUGHTS and POTENTIAL CONCERNS**

Enough Power?
Some people have asked whether the electric motor we used for this tractor is strong enough... It is for us, however, it would NOT be difficult for you to bump up to the next size in motor. In fact, we machined the plates motor housing to fit the bigger motor, You'll just have to change some of the bearing and bushing sizes. (for example, the shaft on our electric motor was 7/8", so.. the bushing we bought was 7/8's inches... on the larger motor, the shaft is 1", so... obviously you would purchase a 1" bushing... your machinist needs to adjust their work to accomodate these changes.)

I have now TWO tractors running to the specifications explained in this document and I've never wished for any more power. Our first electric tractor is now three years old.

We do have a lighter sandy loam on 1/2 the farm and then a river-bottom silt-loam on the bottom half. We also have 4 foot wide beds which we use sweeps and a basket weeder on... I've never noticed any hesitation or lack for power, and I DID notice it when we had the gasoline engine on our original tractor.

Maybe the gas engine was poorly tuned though, but I feel sure that the net power I am getting off this electric machine is MORE than the original gasoline version that we used for 2 summers before converting it. If you have a heavy clay soil and cultivate 6 feet of bed at a time, then maybe this would be too small for you and you should jump up to the next size, obviously I can't speak from experience.

Power Update: We attached five six-inch wide goosefoot cultivators to the tractor, sunk them 4 inches deep into the ground and drove fast back and forth on 300' rows with no lack of power. Although our soil may be lighter than some, this is MUCH deeper than one would normally use for cultivation. I was moving a LOT of dirt. Certainly I could hear that the motor was working harder than normal, but... I could still go as fast as I wanted to in third gear. I just can't imagine a situation that would call for a largr motor.

How many batteries?
On the question of batteries, we have a 48 volt system. On one tractor we have four 12-volt deep cycle batteries, on the other tractor we have six 8-volt batteries. Though both end up with 48 volts, because there is more mass associated with the 8 volt batteries (and 50% higher cost) they will allow us to run the tractor about 50% longer on a given charge.
Interesting to note that niether tractor has ever run low on batteries if they started out fully charged that morning.

On one charge we've seeded dozens of 400' beds with our 4-row Planet Jr. and not noticed any loss of power.... We've never tried to run it out... I don't know that we have enough acreage to do so even if we wanted to. Seeding doesn't take a lot of power.
In regards to cultivation (which requires more battery power because you are moving more soil) I don't think I've ever tried to cultivated more than about 2/3-3/4 of an acre between charges... We run a CSA farm, so everything is growing at different times in different successions. I don't know how many acres I COULD cultivate between charges... or if I am already unknowingly bumping up against the limits... If we had a heavier soil it would probably use up the batteries faster. Buying the six 8 volt batteries wouldn't be that much more expensive than the four 12 volts, and we estimate that they should give us almost 50% longer running time. Base it on your farm size.
we are planning on doing a lot more larger areas of stale seed bedding with the electric tractors this year, so by August perhaps I'll be able to post a better value for exacty how many acres I can basket weed (hopefully with

side sweeps) on one charge. It should be a good test, because we do really fly along with the basket weeders which I assume uses up a good bit of power, and we'll be going through some of the heaviest soil areas on the farm.

What, no clutch?
We disengaged the clutch, because unlike with a gas motor, when you stop the tractor you are also stopping the motor. We don't have any problems changing gears UNLESS we inadvertently leave a LITTLE power running! That is, we didn't turn the accelerator all the way off, so there isn't enough power to move the tractor, but there is enough to lock the gears up.
Obviously, the solution is simple. When we try to change gears, we notice that they don't easily change, and we just turn the accelerator all the way off and then they move easily.

What gear should I use?
Electric motors have very different (BETTER for farming!) torque curves than your original gasoline Allis Chalmers "G" engine. Don't let it make you lazy!! Although you **can** crawl along in third gear at 1/10th mph, you'll use up a lot of battery juice and have to recharge MUCH more quickly. So... remember to shift down for slow jobs even when you don't HAVE to.

If you have an amp-meter, you'll be able to see graphically what gears are most efficient battery-wise for whatever tasks. But even if you don't opt for a meter, you can easily apply common sense. Just don't be sloppy and forget to change gears just because you don't have to!

APPENDIX IV

Thank-You's and Acknowledgements

The first thank you has to go to **Charlie Lomangino,** a master tinkerer and fiddling farmer in the Hudson Valley region of NY. Charlie spent plenty of time showing me how to keep our original gasoline "G" working our first season and a half.

Instead of getting frustrated at seeing I had thrown all his careful instruction out with the old "G" Engine in a fit of rage one day, he offered to help me figure out how to fit the new electic motor I had purchased on in it's place!

We built it with scraps of metal, pulleys and belts pulled from his substantial junk pile, and used a lathe so old I think it was originally turned with draft horses. He spent hours working with me on that first tractor, lending his awesome "tinker" brain to the problems we faced, and I am still using that original tractor today, years later, in it's original configuration.

Bob Battson, of Electric Vehicles of America, has also spent much more time than necessary helping to figure this machine out. He has never been annoyed at my constant inane questions, second-guessing of equipment, corner-cutting, lack of ability to remember part names and repeated loss of instruction manuals. He asked all the right questions before encouraging me to even START our first conversion project, and his original choice of equipment has proven right-on for both tractors. Calling him for help and parts for this project was nothing but dumb luck, but I couldn't have done it without him!

Herman Niekamp, of Niekamp Tool Co. signed on to help design and build the second tractor for this USDA SARE Grant, and stuck with the project even when the funding ran out at a fraction of the hours we had budgeted for the project.

His constant positive attitude, creative mind, and years of experience in the shop has resulted in a bomb-proof (but still easily repairable!) linakge between the old tractor and new electric motor. Although not a farmer, he definitely understood what farmers do to machinery, and very much took that into account in his work.

The **USDA SARE Grant** program is outstanding. The idea of the program is to encourage farmers to try new sustainable agriculture techniques and ideas, and... unlike most governemt programs, this one REALLY WORKS. It works in large part because the folks running the NorthEast SARE program actually understand real farmers and what we need and what we're like... and what we don't need!

They are flexible, encouraging, hand-holding... and their application and summary paperwork is SHORT, logical and MAKES SENSE even to people who have never thought of writing a grant before. If you have an idea you think could improve sustainable agriculture, give this program a try!

APPENDIX V

Final Report for SARE Grant FNE03-472
Converting an Allis Chalmers "G" Cultivating Tractor to an Electric Vehicle

Ron Khosla, 205 Huguenot St, New Paltz, NY 12561
Ph: 845-256-0686 Email: ron@flyingbeet.com
Grant website: www.flyingbeet.com/elecricg

1) Goals

Many small farms rely on older tractors, which can pollute and can also be difficult to maintain. We were to convert an Allis-Chambers "G" from a gas engine to run on electric power, and will then develop materials so that other farmers can do the same thing.

The overall goals are to reduce pollution, improve quality of life, and improve the power and versatility of the original tractor. The plans and instructions will be posted to a Web site and available in printed format for anyone to use.

2) Farm Profile

Huguenot St Farm is a 77 commercial organic farm with about 24 acres under cultivation and about 10 acres in cash crops in any given year. We sell mostly through a 225 members CSA as well as to several local restaurants and one co-op. Before we started this grant we had one operating electric tractor. This grant enabled us to build a second, much better tractor, and to publish the results on the internet so that other farmers could make one as well.

3) Participants

Bob Battson of Electric Vehicles of America wasn't actually listed as a collaborator, but he did a lot of work to make this possible for free. Herman Niekamp was a machinist in Kingston, NY. He devoted many times the number of hours we had budgeted for to vastly improve on the proto-type we had running before. Kathryn Khosla, my wife, and he friend, Happy Porecha don't know much about tractors or machines in general. They were my "test subjects" in trying to make sure that these instructions could be understood by the common person.

4) Project Activities

We built the new improved tractor. It's a great success. Though I went way over budget and spent innumerable hours more than I budgeted in the grant I don't regret it at all! The reward is in having the second tractor to use on a daily basis, and we've also updated the first tractor to be as good as the one we built for this grant.

I also created a website and I've taken a lot of phone calls about this project. Even though the grant is over I plan to keep the website updated as people email and call with questions.

The project didn't change over time, it just took more time to complete than I expected. I originally thought that people would just take these plans to a local machinist and have them make the few components that are not "off-the-shelf". In fact, this is DEFINITELY possible, but it is more time consuming than I had expected. So although I left those instructions in the website/manual, I encouraged people to just order the pieces pre-made from Niekamp Tool Company. I worry a little that this may be improper, since then Niekamp Tool Company would be profiting from the work they did helping me make this grant, but... I don't see any other way around it, and in fact ordering pre-made components from them is actually cheaper than ordering them from a local machinist. Furthermore, I am still including the diagrams and instructions necessary for people that DO choose to go with a local machinist (or to do the work in their own shop).

5) Results

We completed the tractor and made the website and at least one person has already started building an electric tractor based on this website. There are several more farmers that seem to be serious about starting soon, as well as MANY people who have expressed interest and appreciation for the project and some of them may actually build tractors as well.

6) Conditions

N/A, although I do go into much greater detail about the conditions on our farm and modifications that people may want to make to the tractors depending on their soil type and conditions.

7) Economics

The tractor cost a little more than I expected, but not much. It will take people far fewer hours to make the tractor than I expected assuming they order the pre-made machined parts.

8) Assesment

This was a great project. We really learned a lot in terms of pushing the tractor to its maximum potential, and it performed far better than I had even hoped, which is encouraging. I really think that this is an awesome type of Electric Vehicle –FAR more practical than an electric car. It has more power, less breakable parts that over decades have shown they are more robust than gasoline engines. It is economic, it is silent and non-polluting... and on our farm we are proving on a day-to-day basis that it makes us more efficient and more profitable.

9) Adoption

(See above)

10) Outreach

We've held several farm tours that highlighted the electric tractor. People have driven all the way from Missouri and even Ontario, Canada just to see how it works and how well it works. I've taken a lot of phone calls.

Most significantly, I've created a website that goes into great detail describing the tractor. Now that it is REALLY done, I can submit it to search engines and I will be sending out a short "press-release" to several farm publications that had previous expressed and interest in being updated when I finish the project.

11) Report Summary

We converted an Allis-Chambers "G" from its original gas engine to run on electric battery power. The new converted tractor was inexpensive to build and the conversion can be done by inexperienced people in one relaxed weekend. Detailed (and updated) instructions on what to buy and how to build the tractor can be found at www.flyingbeet.com/electricg. The converted tractor is MORE powerful than the original gasoline tractor, is far more robust than the original (and easy to repair if there was a problem) and has additionally proven to be a significant marketing draw for our farm.