BUILDING AN ELECTRIC CAR

HOW A FATHER AND SON TEAM BUILT AN ELECTRIC CAR IN THEIR GARAGE

BY MICHAEL AND NORRIS M. EVANS

2008 --- 2012

Dedicated to all the enthusiastic and creative people in this world.

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Burned out. The LEAF is introduced.

PAGE 121 PART SIXTEEN --- MY "HORSE" IS GONE.

We gave MYEV2 (my "HORSE") away to a High School that had a good Automobile Curriculum.

It was a tremendous learning experience.

Creativity was everywhere --- we immersed ourselves in it --- we enjoyed every moment of that four years --- every moment of getting up before dawn --- while most people were asleep on Sunday morning --- our "Sweet-Spot". Mike and I could not wait to face our next move into the unknown.

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A letter to the people...

080613

MYEV2 ..... HOW A FATHER AND SON TEAM BUILT AN ELECTRIC CAR IN THEIR GARAGE

...and a brief history of...OUR...time...
By Michael and Norris (bud) Evans (the “Sweet-Spot” cowboys)

This is a story...documented as best as we can...that shows how this project was accomplished, how we solved problems, and---while meeting the need---how we paid for it, but,

there's more---

It's our personal reaction to the world and to the uncertainties of global warming. Certainly, we do complain about our own pocketbook---but that's not the half of it---it' the future---we want it back and we want it squeaky clean. So, what can we do? Not much. We're just regular people with regular jobs who buy regular gas. Yes---it's the gas. As a nation, I'm sure that most of us feel this same urgency. As a family, we agree. Mike, my son, was the first to stand up with the idea of the “project”. Get rid of the gas---go electric.

And today, we are happy to report that the “project” is humming (literally), it is alive, and it is well. It has a heart and it is beating with energy. In total, this is a father-sons-daughters-families reaction and this story is told in the words of the father-grandfather-person. It's straight up and we can say that it begins with the past---

Our story starts in June of 2008...more specifically, it was June 8 th. …. that was when the price of gas reached $4.00 per gallon. Like we all did, we caught our breath...but it was really back in 1976, in the film “Network”, that the actor Peter Finch captured this modern moment the best when he convinced the nation to lean out of their windows and shout in anguish “I'm mad as hell and I'm not going to take this anymore!”..... in our case, it wasn't the window...it was the garage door.... but it was the same anguish.

Out of that modern moment came the people's answer to green energy, global warming, and the audacity of the oil manipulators. Our answer is a gathering of electrons.....we build the MYEV2.

PART ONE --- INTRODUCING THE "KEYS"

A gathering of electrons

We start with the obvious and end with the obvious. Let's start here---What's an EV ??--Well, "EV" is short for "Electric Vehicle", and it's mostly understood as being a vehicle powered only by electrons (also called a "stand alone" electric, as no other means of propulsion is provided). The purpose of this project is to build an electric vehicle (EV) that will give us...between charges...a travel distance of about 6o miles. This distance will allow us to go to work and back and make a stop at the grocery store. Incidentally, this also allows us NOT to stop at the gas station (except for friends, coffee, or a "Big Gulp", or, maybe to pick up a few pounds of "gloating"). In addition, and this is very important, we want this vehicle (EV) to operate at freeway speeds, recharge overnight (4-8 hours) and to do this while giving us a very large dose of reliability and consistency. Too much to ask ? I don't think so. We'll even make this project a little more difficult by asking a little more---We make alive the five "Keys"---

KEEP IT SIMPLE
INEXPENSIVE
EASY TO BUILD
EASY TO MAINTAIN
EASY TO UNDERSTAND
(by compartmentalizing function)

In defense of wood, and other topics.

There you have it...except for one thing...which is really the MOST IMPORTANT thing. We would like everybody in the world to be able to do this --- to energize, with passion, their own personal project, it may not be an EV --- it may be other things --- other projects, but things with real meaning and real purpose.

With our own project in mind, and with our "Keys" in tow, we planned, at the very start, to go out of our way to keep designs simple, inexpensive, intuitively obvious, and easy to understand (the "Keys"). I hope we have accomplished this purpose. One more item that we would like to emphasize, and this is the concept of "compartmentalizing function". This is where all the parts that perform a particular job, or function, are grouped together in one spot. We have tried to do this as much as possible.

At first step, we make clear, that Mike and I have more tools then most. This comes from years of collecting tools of all sorts and for all purposes. In the far past, we even started a welding and metal cutting business (BMC Metal Works). We had great passion but little monetary means --- or business sense...? We were much more interested in making things than selling things (I'm sure that this carries over to MYEV2). So that's our background.

With the above said, let's move on ---

We start by saying we resisted doing what we knew how to do. We stayed away from welding as much as possible. Building materials were found mostly in surplus stores or home improvement stores.

Special parts were gleaned from places like hardware stores, surplus stores, junk yards, car parts houses, RV shops or just, simply, our back yards. Finding, designing, and creating things in this way is an exhilarating process --- maybe even approaching the "creative" process (may I be so bold as to say). It's like using your mind to the greatest advantage possible --- which defines the creative process. Creativity is a timid process. Brute force is not allowed. Relax, and you will find the way, allow your mind to drift above the usual rote things of everyday life --- look for new. Simplify. As a consequence, we did just that. We used simple things. We used wood. It's cheap and available. Lots of our original parts were first designed and built out of wood. It will get the job done right now, immediately --- when your design ideas are fresh, pliable, waiting for that final satisfaction of creativity --- which happens a lot. There's always time to change materials from wood, to plastic, to aluminum, or to steel.

PART TWO --- GETTING STARTED --- THE DONOR CAR

We make our first decision --- the donor car.

When solving our self-assigned problem of making a car that will move with electricity alone --- which is certainly tough enough --- we elected not to re-invent the wheel. We decided to use a "donor car". A "donor car" supplies the wheels, suspension parts, drive train components plus all other appurtenances that we are all familiar with in an ordinary vehicle. In "EV" circles, using a donor car is referred to as a "conversion" --- as the donor car is being "converted" from using a gas motor to using an electric motor. Our choice of a donor car leans toward using a lightweight vehicle platform (car talk for a bare chassis with wheels). The donor car should be capable of carrying a significant load. We anticipate that the battery group (the power source for the motor) will weigh a lot. Ever try to lift your car battery? Hopefully, this may change in the future, but, for now, we figure that this significant weight may be our "gorilla" in the living room. We must consider this "gorilla" when choosing a donor car.

So this is what REALLY happened

Our "donor light weight vehicle platform" turned out to be a 1989 ¼ ton expanded cab Isuzu pickup truck. This is good. It's light weight and it can carry 4 people. The Isuzu was a family hand-me-down. We lucked out. Pickup trucks are convenient for conversion purposes because they are designed to carry heavy weight over the rear axle. We were lucky. But if you aren't this fortunate, be prepared to spend somewhere between $500 to $1000 for a suitable vehicle. The good part is that it doesn't have to run --- the bad part is that you still have to find a way to get the vehicle in your garage.

As a ¼ ton pickup, our donor truck was designed to carry only 500 lb. over the rear axle. We need more capacity than that, much more --- so we look forward to solving this problem. On the good side, the truck comes with a vinyl bed liner --- which we will put to good use later.

Before we really get started, let me tell you about our limitations ("our", meaning Mike and myself). Since there is just the two of us, there is no third party assigned the task of photo-documenting this whole episode. Documentation was always a second thought. As you might expect, we would get involved in what we were doing and would forget the camera. If you look really closely, you'll see some photos that are out of chronological order but we will use these photos because they feature some particular part or purpose. We are not professionals, but here goes.

Our first photo is one of those “out of order” shots.

Figure 2 – 1 shows our donor car with a wooden feature in the bed of the truck. The wooden feature should not be there, but we felt the need to show the side view of the donor truck.

Figure 2 – 2, shows the empty truck bed, minus the vinyl bed liner.

The donor car.

Figure 2 – 1 The donor car (truck).

Truck bed.

Figure 2 – 2 The empty truck bed.

We do “heavy springs and adjustable air shocks”.

That's our solution to the overload problem, heavy springs and overload shocks. This is definitely something to keep in mind when you're looking for a donor car. The donor vehicle may need to be modified to carry a significant battery load (that “gorilla” that we referred to earlier). In our case, and to our future amazement, the total battery weight turned out to be about 1800 lb.---significant. That was, of course, according to the technology available in 2008. Today, lighter weight battery systems are available --- but costly. So with this demand for a significant increase in carrying capacity in mind, we had no recourse but to modify the Isuzu's rear suspension. We found an independent mechanic who specialized in heavy suspension problems related to class “A” motor homes. Perfect. Cost was about $1000.

Figure 2 – 3 and Figure 2 – 4 shows the rear suspension modifications. The number and thickness of the leaf springs were increased considerably, and the new “U” bolts are up graded plus the addition of adjustable air shocks.

Air shock.

Figure 2 – 3 New leaf springs and air shocks.

Heavy leaf springs.

Figure 2 – 4 New “U” bolt and support piece.

The air shocks are adjusted via air pressure through a pressure valve located where the gas filler spout used to be (where else?). Figure 2 – 5 and Figure 2 – 6 shows the location and detail of the air pressure valve.

Flip open gas door.

Figure 2 – 5 Gas filler location.

Air cap.

Figure 2 - 6 Air pressure valve detail.

Forget the 200 psi Max pressure. The best we could do was about half that or about 100 psi, which seemed to be adequate for around the town and slowing up for potholes and speed bumps. So far, so

good --- we seemed to have solved the overload problem ---but what's next? We looked for help and found it through the internet.

We found a company on the east coast that specialized in homemade electric cars. This was ELECTRIC VEHICLES OF AMERICA, INC.,(or EVA), located in New Hampshire, ZIP 03894. For more information, checkout their website: www.evamerica.com., or, contact them via EMAIL: EVAmerica@aol.com. Nice people well versed in the mechanics and electronics of EV conversions. Their suggestions and knowledge proved essential for our project's success --- that is, making a machine that will allow us to drive down the road at 60 MPH with no gas.

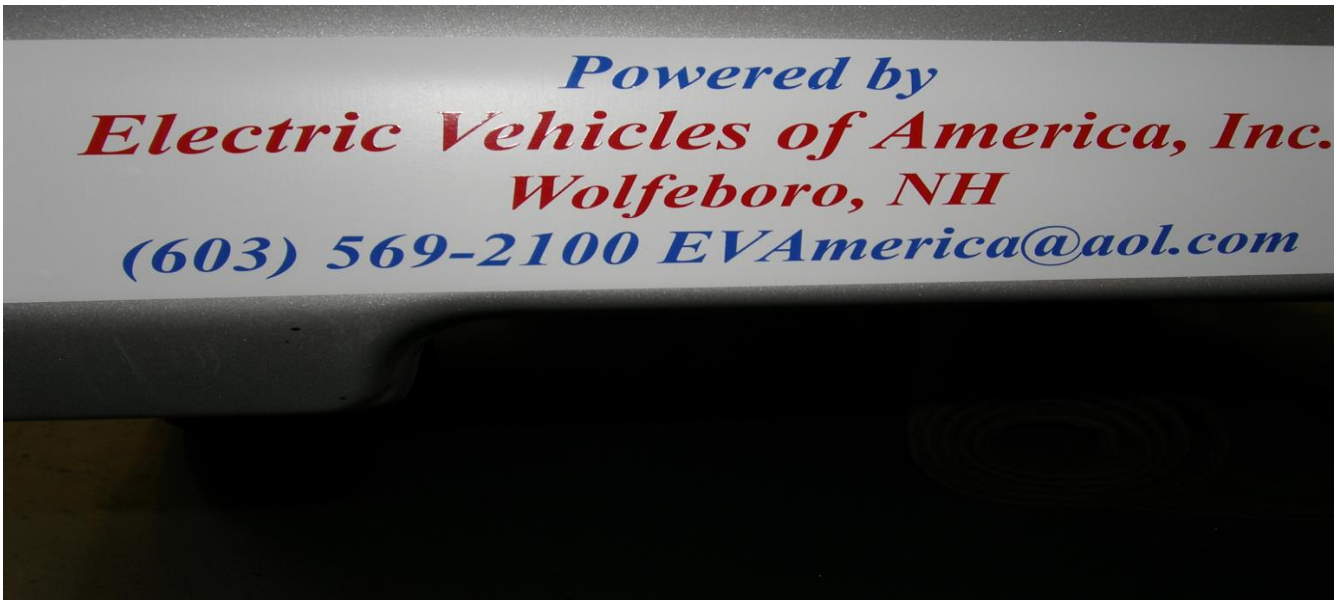


Figure 2 – 7 This is our bumper sticker.

We wake up to the realization --- "The Money"

It wasn't but a short time later, after we had contacted EVA, that we quickly awoke to the fact that "MYEV2" (the "project") was going to cost some money. So we "surfed" for money. We found "VISA". Keep in mind that all this was happening back in 2008---just before the financial crises surfaced --- we had no idea of what was to come --- but, supposedly, neither did the banks. We were able to get a low percentage loan. So we did. With EVA's help, we guessed at $15,000.

PART THREE --- ORDERING PARTS FOR MYEV2

So this is how we spent the "The Money".

It's the parts Yes, it's that long list of parts, the electronic and electromechanical devices that we bought. All of these items are necessary for the EV to function. The following is our list as determined by ourselves and the invaluable help of Electric Vehicles of America, Inc. --- EVA.

144 V SYSTEM - TRUCK PACKAGE
USING 6V BATTERIES

QTY	DESCRIPTION	UNIT PRICE	TOTAL PRICE
	DRIVE SYSTEM		
1	FB1-4001A Advanced DC Motor with dual shaft	$1,550.00	$1,550.00
1	1231C-8601 Curtis Controller (96-144 V) 500 Amp Limit	$1,495.00	$1,495.00
1	Aluminum Plate/ heat sink compound/12v fan	$50.00	$50.00
1	PB-6 Curtis Potbox	$90.00	$90.00
2	Albright Contactors SW-200	$150.00	$300.00
1	Adaptor Plate with Spacers (2) Manual Transmission - Clutchless	$400.00	$400.00
1	Motor Coupling (Aluminum) Manual Transmission - Clutchless	$325.00	$325.00
1	Motor Mount Assembly	$180.00	$180.00
	BATTERY SYSTEM		
1	Zivan NG3 Charger 2800 watts 230VAC input 144VDC output	$1,030.00	$1,030.00
48	Battery Terminal Protective Covers (Red & Black)	$1.50	$72.00
75	2/0 Cable - 50 ft Black, 25 ft Red,	$4.00	$300.00
70	2/0 lugs - Magna lug (64 straight + 6 90 degree)	$2.50	$175.00
9	ft Heat Shrink	$6.00	$54.00
	INSTRUMENTATION		
1	80-180 V Voltmeter	$65.00	$65.00
1	0-400 Amp Ammeter	$65.00	$65.00
1	50 mV Shunt	$30.00	$30.00
	POWER BRAKES		
1	Vacuum Pump (12V)	$225.00	$225.00
1	Vacuum Switch	$135.00	$135.00
1	In-line Fuseholders	$5.00	$5.00
	SAFETY		
1	Astrodyne DC-DC Converter (132-372V) with relay and SB-50 (370V max)	$280.00	$280.00
1	Tilt Bed Package - 200 lbs 15 inch stroke (Gas lifts, hinges, reinforcement, instructions)	$200.00	$200.00
14	Ft - 1 1/2 inch clear vinyl hose for 2/0 cable protection	$1.50	$21.00
10	Insulated Metal Clamps for Vinyl Hose	$1.00	$10.00
1	Electric Hot Water Heater Components (Heater, mount, contactor, Anderson SB-50 connector, fuse)	$350.00	$350.00
1	Littelfuse L25S-400 - Power Fuse	$55.00	$55.00
1	Littelfuse holder	$25.00	$25.00
1	KLK-20 Fuse & Holder - Control Fuse	$20.00	$20.00
1	Pair Anderson connectors SBX-350	$64.00	$64.00
1	Fuseholder (4) - Control Board	$15.00	$15.00
1	First Inertia Switch - Auto Shutoff (12V Sys)	$45.00	$45.00
	SUBTOTAL		$7,631.00

The total above is an approximate number and may or may not reflect the various charges for shipping, charge backs, freebees, etc.. As inferred from the above parts list, EVA suggested that we go with a power source comprised of 6-volt batteries instead of 12-volt batteries. This choice, it was cited by EVA, will increase our desired driving range.

So be it. We slowly gathered the parts.

figure 3 – 1 The red item, top, is a heater part.

Figure 3 – 2 The silver item is a brake part.

Our second decision --- which battery type.

We needed 24 of these 6-volt batteries to bring the voltage up to the 144 volts required for our motor. So it was up to Mike and me to decide what type of 6 volt batteries to choose. It was ours to decide. We had no idea. We did have choices. It was either ordinary car batteries --- the lead-acid type that required distilled water (the term in the trade is "flooded"), gel batteries (sealed, no water added), or possibly the new lithium ion, such as Lithium Iron Phosphate.

We quickly eliminated the lithium ion, as this type was far too expensive for our budget. The sealed gel type of battery seemed very inviting but there were charging considerations at higher voltages that we, frankly, did not understand. We ultimately went with the familiar lead-acid (flooded) type, as they were the least expensive and had a track record of being reliable and durable under semi-harsh conditions, i.e., the dreaded "golf cart" conditions.

We visit the "Trojans"

Of the several battery brands we considered, we chose Trojan (www.trojanbattery.com). The EVA folks described Trojan as reliable and stated that their products were "known for their quality and performance". That was enough for us. Of the various products available, we chose the Trojan "Signature" line, deep cycle, flooded. This led to actual model numbers. We considered the T-105's, the T-125's, and the T-145's. The T-105's were the smallest of the three whereas the T-145's were the largest. The T-105's were also the lightest by weight at 62 lb. each but also had the smallest energy rating. The T-145's had the highest energy rating but also had the highest weight at 72 lb. per battery.

We opted for the T-145's in spite of the increased weight. We decided to err on the side of range because we wanted the increased range for our “daily driver”. So we finally decided on a set of twenty-four T-45s. Our “final answer”.

We “Dodge” a bullet

With the battery type decided, Mike located the best deal possible via the internet for a set of Trojan T-145's. One of these “babies” comes in at 75lb wet --- 24 of them will tip the scale at 1800 lb. --- and, to add a little thumb to the scale, $4000 the set. That WAS a big gulp, but we knew it was going to be expensive and we did have money in the bank for that purpose. The deal was done.

That was good, but the batteries were located some 75 miles away. That was bad. Since the price of shipping was not included in our budget, we massaged my 1978 Dodge 300 (1-Ton) Maxi Van and went for a ride. Needless to say, we “Dodged” a bullet, as the 30-year-old Dodge performed stunningly well at its maximum load capacity. We made it home --- all 24 “babies” in tack --- and the wheels still turning on the Dodge.

The “Array”

Figure 3 – 4 shows all 24 Trojans, arranged in rows and columns and sitting in the corner of the garage. So now what do we do? The question is how --- and maybe even why --- should we put the 24 batteries (all 1800 lb. of them) into or onto the truck?

We were led toward our answer by looking at what other EV builders had done. Surprisingly, there is a source for this information. That source is a web site that looks like it has actually categorized every single battery-operated vehicle in the world. That's right --- the world.

It's www.evalbum.com. Look it up. You'll find every sort of EV that you can imagine. Overall, you'll find that people will, in general, solve this and other problems according to their own individual requirements, their individual needs --- we call this their building criteria. Mike and I have our own building criteria. Remember those five “keys” --- that's ours.

Keep it simple, inexpensive, easy to build, easy to maintain, easy to understand.

The array.

Figure 3 – 4 Our Trojans, standing at attention in rows and columns.

Looking through the "EV-Album" web site, you might notice that most people will opt toward distributing their batteries throughout the vehicle's chassis. This certainly makes sense because of the weight problem. Notice that some people will spread the battery locations between the front (where the radiator used to be) and toward the back (where the gas tank used to be). Here are a few examples.

Figure 3 – 5 Gas tank placement.

Figure 3 – 6 Tilting truck bed for access.

Figure 3 – 7 Inside of truck frame.

Figure 3 – 8 Radiator placement.

In our case, the question of battery placement finally resolved itself automatically via our own build criteria. Remember --- it has to be simple and easily maintained --- which encompasses the total reason

for compartmentalizing the EV parts. In so doing, we decided to pay the "weight price" for simplicity --- as long as it advanced the concept of compartmentalization. We elected to put all the batteries, four rows of six, in one location --- in the bed of the truck, as close to the cab of the truck as possible. That was our "Array" .

PART FOUR --- WE START BUILDING MYEV2

The "not-so-pretty box"

So we have 24 batteries located in one place, right behind the truck cab. It was four batteries wide between the wheel wells and six batteries long. Widthwise, it definitely was a squeeze, but we could handle it. Since the total battery weight was to be 1800 lb., we needed a strong box to contain the array. We used wood for the box. We chose Douglas Fir and exterior grade plywood --- just as if we were building a house. It was 2"x 4" lumber and plywood of various thicknesses. It certainly was no "NASA" but just, maybe, it was a little "Orville and Wilbur". It felt good.

Figure 4 – 1 The "not-so-pretty-box"

We jettisoned the Isuzu vinyl bed liner (it took up precious width space between the wheel wells) and, instead , confiscated the hard rubber industrial mat that we were standing on and sized it to cover the floor of the box. We figured that this ¾ inch thick, ventilated, industrial mat would provide some means to keep the batteries from moving, even though they were reasonably snugged together. We had no doubt that the box was stout --- with the possible exception of having to use 1/8-inch-thick plywood

on the sides, where the box was squeezed against the wheel wells. Space was running out. In the end, it all worked out. The rest of this "EV Experiment" was built around, attached to, or, in some manner, was, or would be, connected to this " not-so-pretty box".

We confess that building this project was hard work. We enjoyed the work, but it was time consuming. Finding quality time was difficult --- too many day jobs --- too many everyday but necessary duties. Family wise --- it was a little tense --- but Mike and I were saved. We discovered a secret.

The "Sweet Spot".

Shortly after completing the battery box, we inadvertently discovered the existence of the "Sweet Spot". The use of "Sweet Spots" proved to be an absolute necessity if we were to have any chance at all of finishing our project. Our "Sweet Spots" would show up only once a week and would last for about four hours. By definition, a "Sweet Spot" occurs when the majority of people surrounding you are either asleep or are preoccupied by some other event. In our case, it was the former --- being asleep. Because of this, Mike and I were able to use "Sweet Spots" for four years straight. We very rarely missed a "Spot". It was a regular occurrence. Our "Spots" would take place on Sunday morning between the hours of 5 AM and 9 AM …. Happy times …. We were dedicated.

During one of those early Sunday morning efforts, and as we were hustling to strip down the Isuzu of all of its non-essential parts, we luckily reminded ourselves of a previous instruction by EVA. This instruction was to make one final measurement before removing the motor and drive train from the donor car.

Figure 4 – 2 Before

Figure 4 – 3 After.

The "Measurement". (We stop dead in our tracks)

At first, it seemed to be a little ambiguous or even silly, but, after some thought, we realized that EVA's "Measurement" suggestion was actually the connecting link between the "gas" donor car and the "electric" donor car. We thought it ambiguous because the measurement could be almost of any size and that it might occur almost anyplace. It doesn't matter --- as long as the "Measurement" is made

before the gas motor and drive train are removed from the donor car. But before telling you the location to make this measurement --- let's talk about why we need this measurement.

WHY: We need the "Measurement" because it enables the electric motor to be set in exactly the same place and orientation as the gas motor it replaces.

WHERE: Pick a spot on the top of the clutch housing flange where it mates with the gas motor. Mark that spot. From that marked spot, measure vertically up to someplace on the donor car body. This will probably be somewhere on the firewall. Mark that spot. Now note the distance you measured and write it down on the car firewall next to your chosen spot. Done.

Figure 4 – 4 Note the duct tape, upper left. It has the "Measurement" written on it.

So we finished stripping down the Isuzu. We mourn the passing of the old but reliable Isuzu but turn around and celebrate her rebirth --- we produce the MYEV2. Our next job --- the electric motor.

This is what we have been waiting for. The electric motor is the symbol of our collective energies. We make the call for delivery. The motor is the product of Advanced D.C. Motors, Inc.. The model number is FB1-4001A. It is designed with dual output shafts, each about 2" long extending from either end. The body of the motor (excluding output shafts) is about 17" long, and the diameter of the motor housing is about 9.1 inches. Weight is about 143 lbs. It is designed to operate at 144 VDC with

a peak output of 100 H.P. The advertised applications are uses such as commuting in city traffic, driving in areas of hilly terrain and transporting heavy objects. Cost is $1550. in 2008 dollars. Advanced D.C. Motors, Inc. --- Wed Site: www.adcmotors.com and Email: info@adcmotors.com. Their U.S. Office is located in East Syracuse, New York. We arraigned for delivery through our contacts at EVA.

The motor is shipped. Let me explain. I (Dad) live in an older bedroom community. Kind of "sleepy" --- if you know what I mean. The streets are crooked, narrow, but asphalted. No sidewalks, no curbs --- just oak trees --- get the picture? So here comes an 18-wheeler. It's the delivery truck for the EV motor. I live near the top of a hill. So the 18-wheeler finds itself draped over the top of the hill like a wet noodle over your thumb. Traffic stops (there was no traffic). I was sweating. So I told the driver to just drop (put) the wooden crate on my dirt driveway. Everything was cool. The driver and truck disappears over the hill and I never saw him again. I have no idea how his 60' long combo found his way out of our sleepy community. The crate was really heavy, like glued to the ground. It probably weighed in at about 170 lb. including crate. I couldn't move it.

Figure 4 – 5 The electric motor in the delivery crate (170 lb.).

The "Two Garages"

I suppose that this is the time to explain that this story takes place between two garages --- mine and my son's. We're about 30 miles apart. Mike has the donor car in his garage. My job was to be the designated receiver of the freight-delivered items because I'm retired and home alone. So my job was to pick up the crated motor, put it in my truck (yes, the Dodge) and deliver it to Mike's garage. So, as you might expect, this was easier said than done --- so keep this circumstance in mind, if you decide to do the same. Long story short --- the crated motor got to Mike's garage via a steel ramp, a hand winch, and the Dodge.

The visit to " Partsville"

Yes, I delivered to "Partsville"--- 30 miles away to be Mike's garage. On a dolly, the crated electric motor rolled into Mike's garage. Floor space was at a premium. Except for the Isuzu motor, most all of the Isuzu parts were loose and spread out all over the floor. But let it not be said that we didn't find room to open the wooden shipping crate and high five our pleasure at seeing that magnificent piece of work, the electric motor.

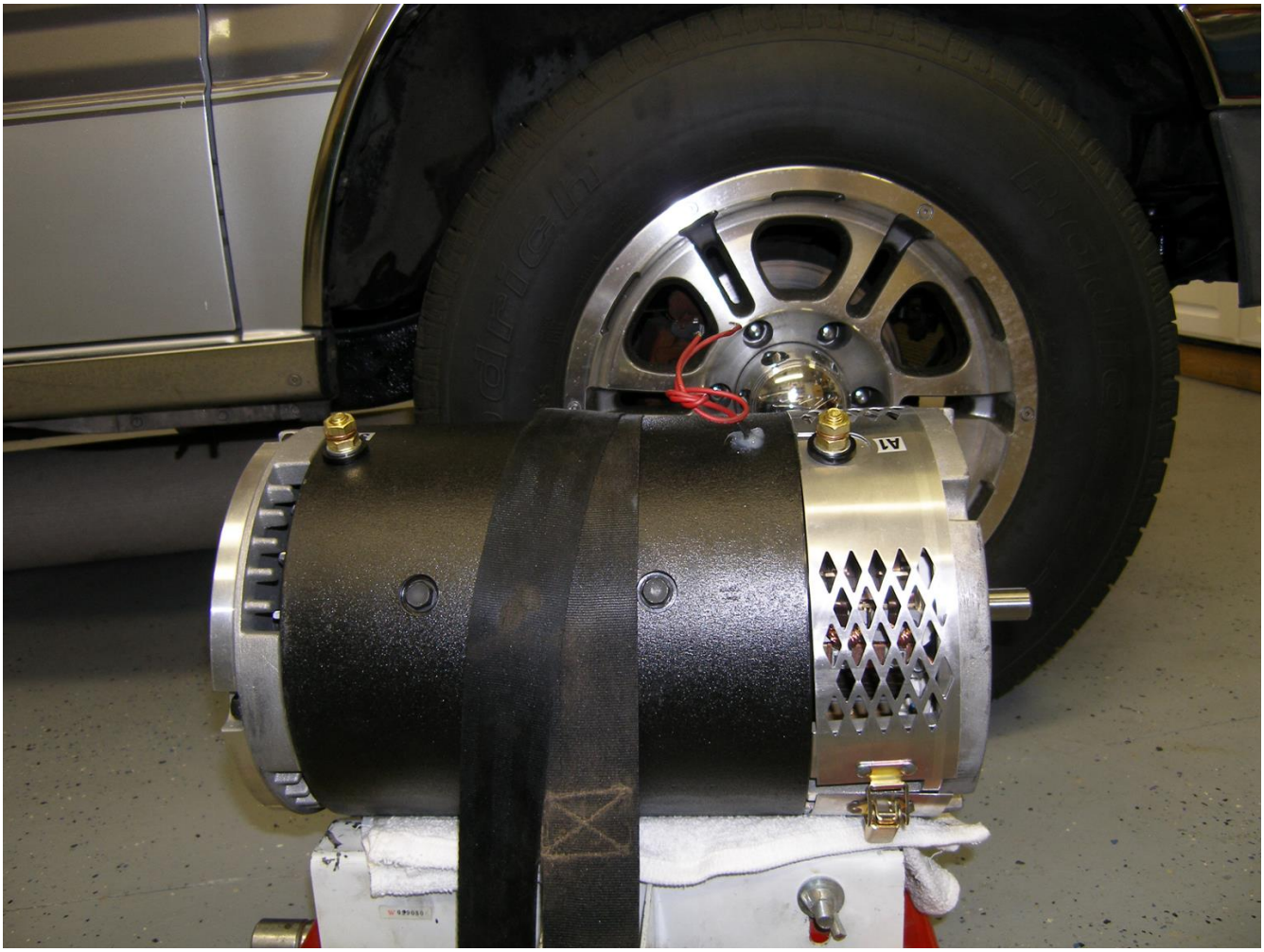


Figure 4 – 6 Compare the size of the electric motor with the size of the truck wheel.

PART FIVE --- " MARRYING" THE MOTOR

What's next ?

We marry the electric motor to the Isuzu drive train.

Our next move is to bolt the electric motor to the old gas motor clutch housing --- but that's not going to happen. The bolt patterns don't match. Fortunately, EVA was way ahead of this problem. They have a transition plate already made. Cost is $325. It was beautiful. It came as an aluminum square plate, ½ " thick. This transition plate has mounting holes pre-drilled to fit our particular electric motor --- but no holes pre-drilled for the Isuzu clutch housing. We have to locate and drill these holes

ourselves. We can do this by match drilling the transition plate through the existing clutch housing holes. We do this by first aligning EVA's transition plate to the old Isuzu clutch, then drilling through the clutch housing holes --- but not so fast. Earlier, when counting our dollars, we decided not to include the clutch --- now what.

We “throw out the clutch”.

Yes --- we throw out (as in throw away) the clutch. It's too expensive to keep. EVA sells the parts needed to keep the existing clutch, but this modification would cost about $1300. That's too much for our pocketbook. So, it’s back to our great grandfather's day --- gear clashing without a clutch --- it can be done --- they did it --- we can do it --- we smile and move on.

Figure 5 – 1 Only 1, 2, 3 and R are used.

Surprise --- EVA supplies the parts for a clutch-less manual transmission --- $400 . This includes a motor-transmission coupling (again machined from that beautiful 1/2” thick aluminum) and all the necessary additional parts. So we throw out the old parts --- put in the new parts --- and anticipate the next job ahead.

Figure 5 – 2 The stock Isuzu transmission and clutch housing showing the protruding transmission shaft.

We begin the process of working up the drive train components.

If you haven't noticed, the transmission and clutch housing assembly is green. It's a green that's straight out of the corner car parts store, a spray can.. That's Mike's idea and Dad loves it. We even started to wear green shirts for every one of our “sweet spot” sessions --- it was our “ uniform ”.

Along the way you'll probably notice that other parts are also green --- spray cans are pretty easy to use. Once the old parts are washed and cleaned of every speck of grease, then the next and obvious idea is to paint it --- ask any person that’s served time in the Army, Navy, Air Force, or other Service.

Figure 5 – 3 The newly refurbished EV transmission.

The transmission assembly is sitting on blocks so as to clear the transmission shaft from touching the concrete floor.

Figure 5 – 4 The clutch housing sitting on top of the transmission-motor transition plate.

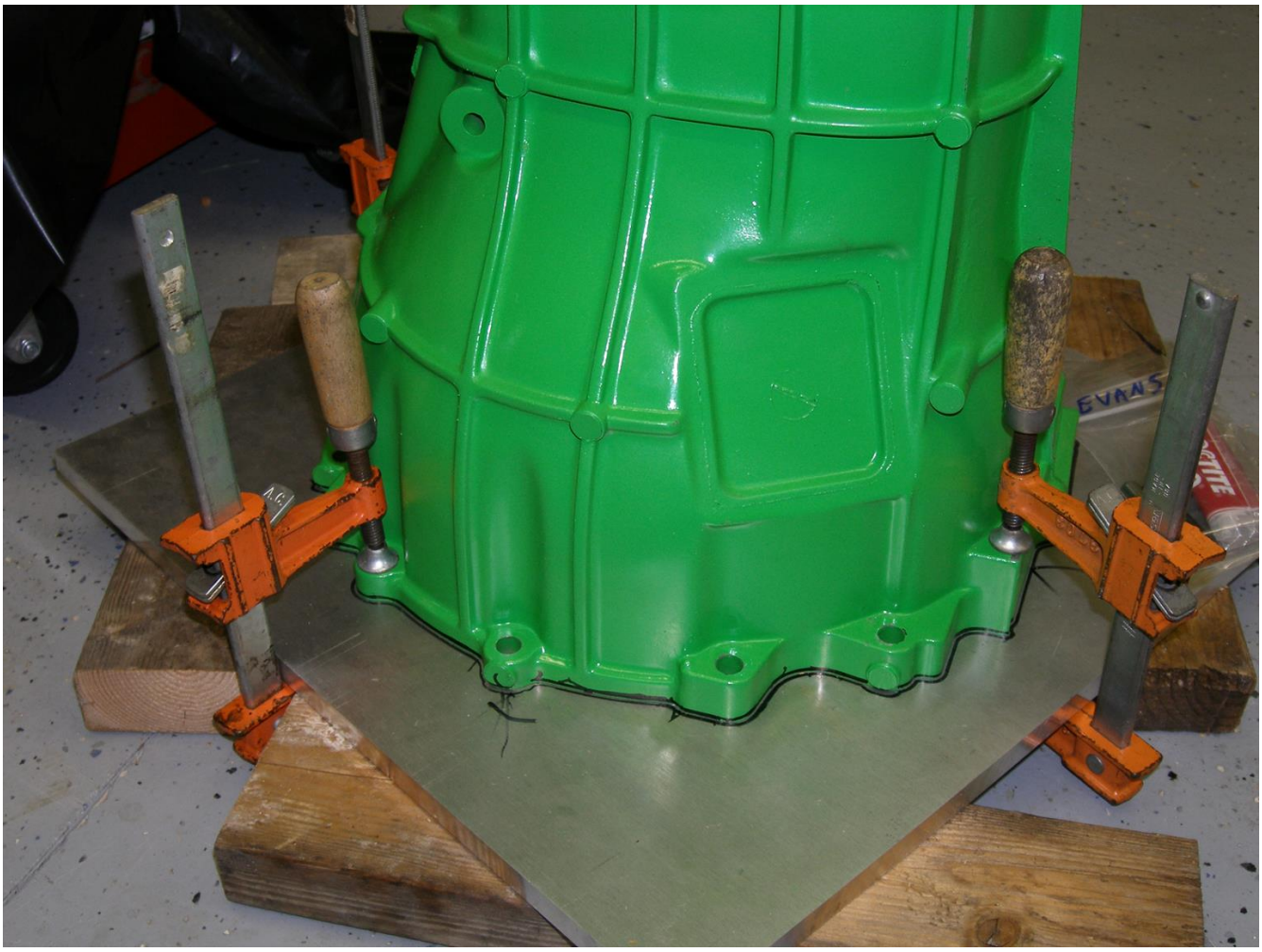


Figure 5 – 5 Detail of the 1/2" thick aluminum transmission plate securely clamped to the clutch housing face.

Our next step --- Match drilling

This job was relatively simple --- but scary. We made it this far, and we did not want to make any unforced alignment errors. These mounting holes had to be dead on. We figured that match drilling gave us the least possibility of error --- as long as all the parts were first aligned properly and stayed that way.

The other alternative would be to mark all the hole locations, remove the plate from the assembly and use the drill press to drill the holes. This method has the real problem of the drill bit walking away from its intended location. Even if the hole location is carefully marked and precisely pre-punched and even pre-drilled with smaller diameter drill bits, precise hole location is still a challenge. The problem dramatically gets worse when there are several hole locations to be drilled in the same plate --- as we have here. The garage mechanic, using typical hand tools, has no chance to do this job. His only out would be to widen the diameter of the drilled holes, thus compensating for miss alignments. We did not want this. Match drilling eliminates this problem.

With this scary thought in mind, and the additional thought that the aluminum plate cost us $300, we carefully commenced with the job. We used a handheld electric drill and did not hesitate. Perfect.

The next step --- we make a “flower”.

We kept the transmission assembly in place, still upright on the floor and the aluminum transition plate still clamped rigidly together. We knew that, sooner or later, we had to shrink the size of this transition plate (it comes from EVA as a square plate). We needed it smaller so the plate would fit within the body structure of the car.

We traced around the clutch housing and later enlarged this tracing about an inch all-round the perimeter. We removed the plate from the clutch housing so we could conveniently cut the 1/2” inch thick aluminum on the work bench. It was a job. We used a handheld scroll saw with a fine-toothed saw blade that was sized for aluminum. We went slow and finished the operation with a file and sandpaper. It was a beautiful shiny flower, but, a word to the wise, this work could have been done in a much simpler manner and still clear the body structure. We reattached the “flower” to the clutch-transmission assembly and were ready to go to the next job.

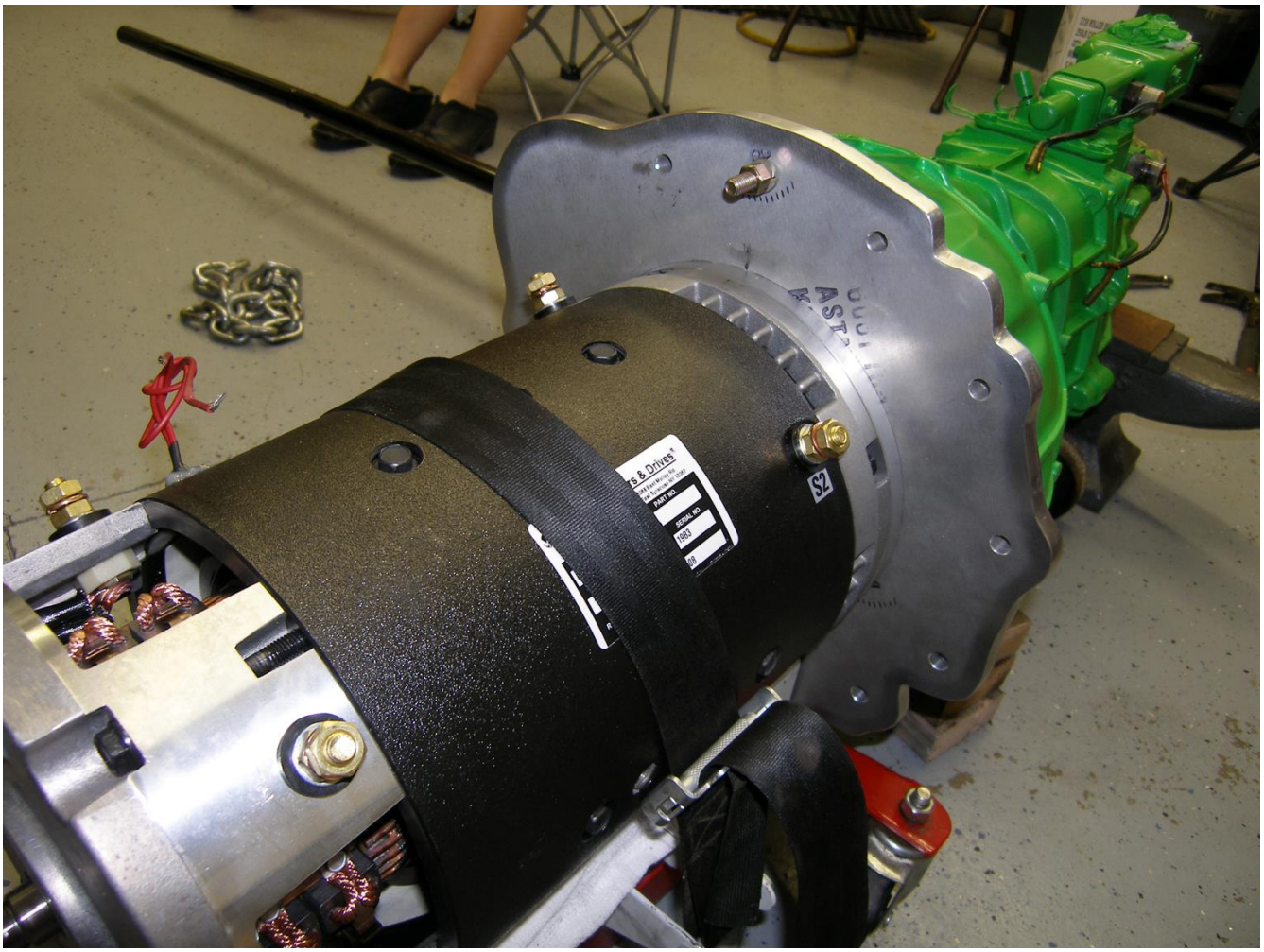


Figure 5 – 6 The “flower” as assembled between the motor and the clutch housing.

Next --- We prepare to “set” the motor into the motor bay.

When we say “set”, we simply mean that we want to position the electric motor in exactly the same position as the gas motor was before the gas motor was removed.

We're ready.

The electric motor, clutch housing, and transmission assembly are all bolted together. Lifting the entire assembly off the floor and into the Isuzu's engine bay will be done by a shop crane. The motor is securely strapped to the transmission jack and the motor assembly plus the transmission jack, will be lifted as one unit. Note the long bolt through the top of the clutch housing and through the aluminum plate. This bolt will be used to pick up the entire unit.

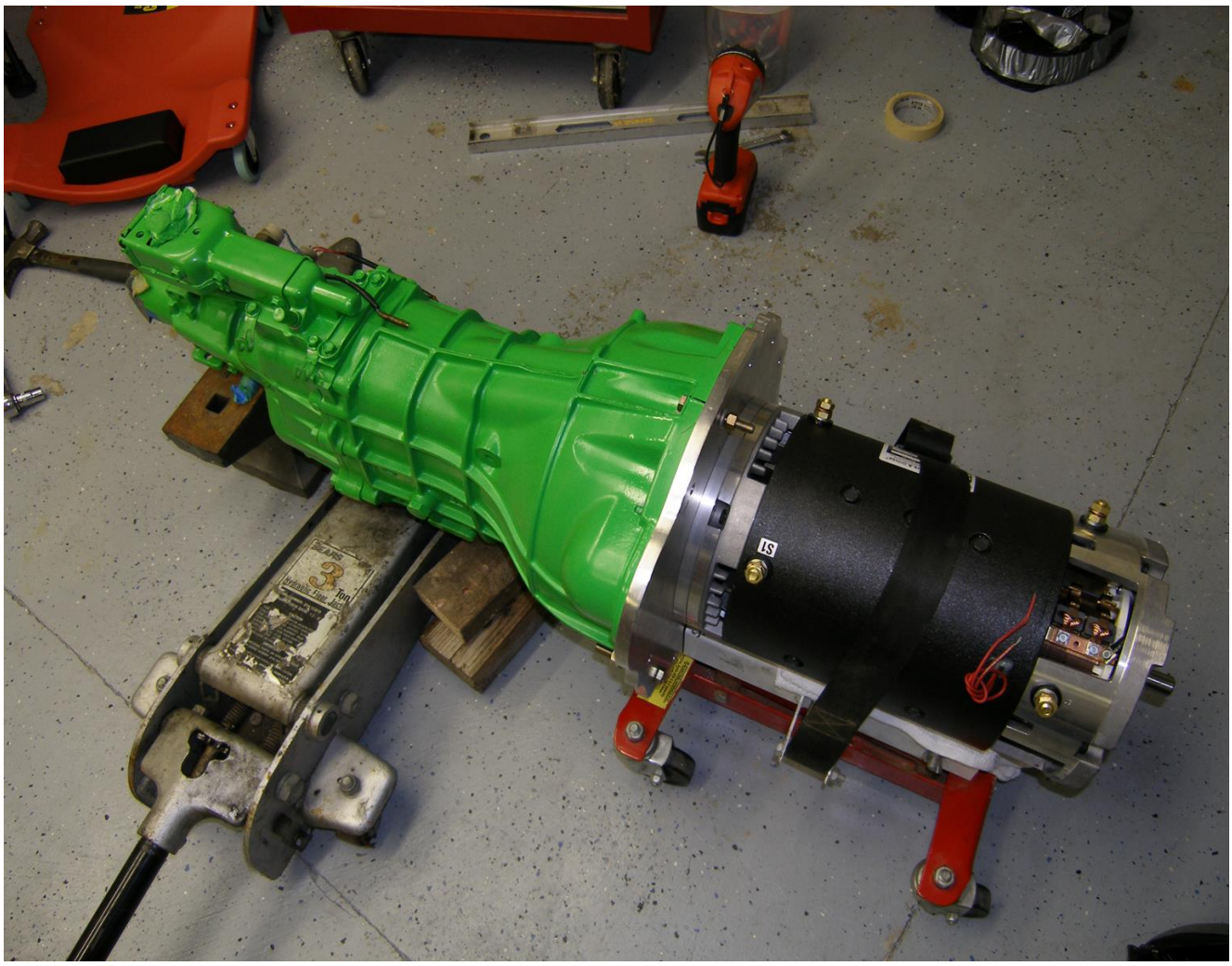


Figure 5 – 7 With the pickup bolt in place, the entire unit is ready to be lifted into the motor bay

We prepare the motor bay.

Figure 5 – 8 The motor bay as the motor sees it.

Figure 5 – 8 is a little seen view of the engine bay. Mike must have hung by his toes to get this one. The bright little spot in a field of black is the drive shaft waiting to be matched up with the transmission tail shaft. Below the drive shaft spot is the chassis cross member that will support the weight of the transmission tail shaft. That cross member will be our target when we slip the motor assembly into the bay. The strange looking round tube sitting on the floor is a rolled-up rug. See, I told you we weren't professional photojournalist.

It's important to note that the rug has no part in the EV making operation. I don't know what happened to the rug --- but by the time we got through with all the grease and dirt available in the garage, it will have absolutely no value other than to keep our feet warm on the concrete floor. Before setting the motor, the rug will be gone.

Next, Figure 5 – 9, shows an overall view of the motor bay. In the fore front is a chassis cross member that shows the gas engine motor mounts attached to either end of this cross member. For now, we will keep the stock mounts in place. Eventually, these Isuzu mounts will be replaced with mounts that fit the electric motor (the rug is now spread out flat).

Figure 5 – 9 The motor bay ready for the placement of the electric motor (minus the rug).

Using the motor crane, we lift the motor- transmission assembly and rotate the assembly so that the aft end of the transmission will be the first part to slip into the motor bay. The tail shaft will be pointing down and aimed at the rear cross member. With the transmission foot resting on the cross member, we lowered the remaining weight of the assembly onto the attached transmission jack. As a safety precaution, we still have the crane attached to the assembly, but the crane carries no weight.

"The three points".

The next step was to loosely bolt the transmission foot to the cross-member. We do this so the aft end of the transmission will largely stay in place while we finely adjust the position of the motor (up, down, or sideways). If you remember geometry 101, you will be familiar with the fact that it takes just three points to define a plane in space. We use it here. One point of the three is the aft end of the transmission. It's the foot that we loosely attached to the chassis cross-member. Remember we need two additional points to position the plane of the motor. These two additional points will be the two feet that we will now attach to the motor via the Motor Mount Assembly.

We find the Motor Mount Assembly that EVA sent us. This piece comes in at $180. It's a ¼ inch thick, 2" wide circular steel strap that is designed to encircle the motor. This circular strap has two "Tabs" of ¼ inch thick steel welded to it. These "Tabs" are sometimes referred to as "feet". The Motor

Mount Assembly is made to go around the motor and stay in place by friction as you tighten the bolt attached to it (similar to a very large and heavy hose clamp). We put the Motor Mount Assembly onto the motor and rotated the assembly so that the tabs (feet) point to the bottom.

Figure 5 – 10 EV parts. The air shocks, left, and the round Motor Mount Assembly (with tape)

"Setting" the motor with the "Measurement".

The motor is now ready to be "set" in place. When we say "set", we simply mean that we want to position the electric motor in exactly the same position as the gas motor was before the gas motor was removed.

We can do this by simply adjusting the transmission up or down. This is done by cranking the adjustment screw of the transmission jack that is taking the weight of the motor. Our job is almost done. We just crank the adjustment screw on the transmission jack so that the "Measurement" between the mark on the clutch housing and the mark on the car body (the fire wall) is the same as that celebrated "Measurement" (that we "poo-poo"ed earlier).

In case you're wondering, the sideways positioning is largely done by eye. This measurement is only

important if the angle of the motor is grossly out of alignment with the center line of the car; trust your eye. Holding everything in place can be done by inserting two wood 2"x 4"s (or lumber of equal size) on either side of the motor in a "V" shape. Try to keep the wood pieces at equal angles while leaning them against the stock Isuzu motor mounts. Cradling the motor in this "V" will help maintain the stability of the motor in the centered position. Adjustments may be necessary if the elevation of the motor was changed during this process. Always Check You're Work Repeatedly --- ACYWR.

Figure 5 – 11 Stabilizing the motor in a central position.

When all is adjusted to your satisfaction, then the motor is "set" and is ready to be secured to the chassis. At this time, the aft foot of the transmission can be bolted securely (ACYWR). What remains is to attach each foot or tab of the motor to the chassis of the Isuzu via the building of new motor mounts. This is our next job.

PART SIX --- BUILDING NEW MOTOR MOUNTS

Forget the old gas motor mounts. These have flexible arms and will tear apart under the starting torque of the electric motor. We need solid mounts.

The old motor mounts.

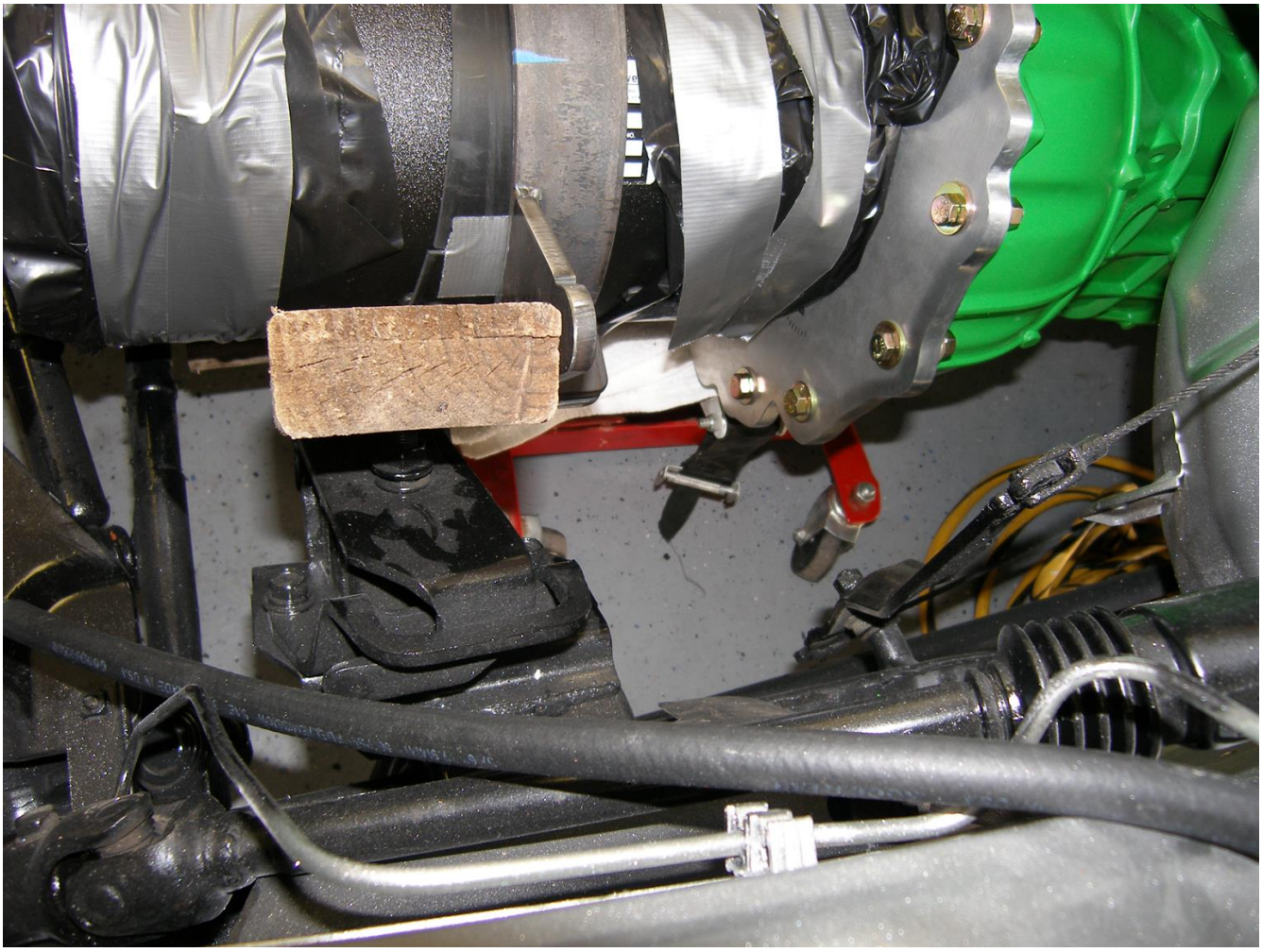


Figure 6 – 1 One of the stock (flexible) Isuzu motor mounts beneath the wooden board.

The stock Isuzu motor mounts will be removed and not used. The new EV motor mounts that we will build, will be attached to the same chassis mounting spot (flat) as used by the old Isuzu motor.

<u>We consider the motor mount material.</u>

Right off, the material that we will choose must be very similar to the material used by EVA for the Motor Mount Assembly. This was ¼ " thick steel. That's the starting point.

<u>What we need and what the Isuzu gives us.</u>

We need two motor mounts, one left, one right. Each new motor mount will consist of one base plate

and one arm. The base plates will be bolted to the original Isuzu motor mount positions --- which are flat spots that are built into the Isuzu chassis, one per side. We call them “flats”. Each Isuzu flat has two bolt attachment points about 6” apart. The new arms will be of our own design --- not identical --- but mirror images of each other.

Starting off, the mounts.

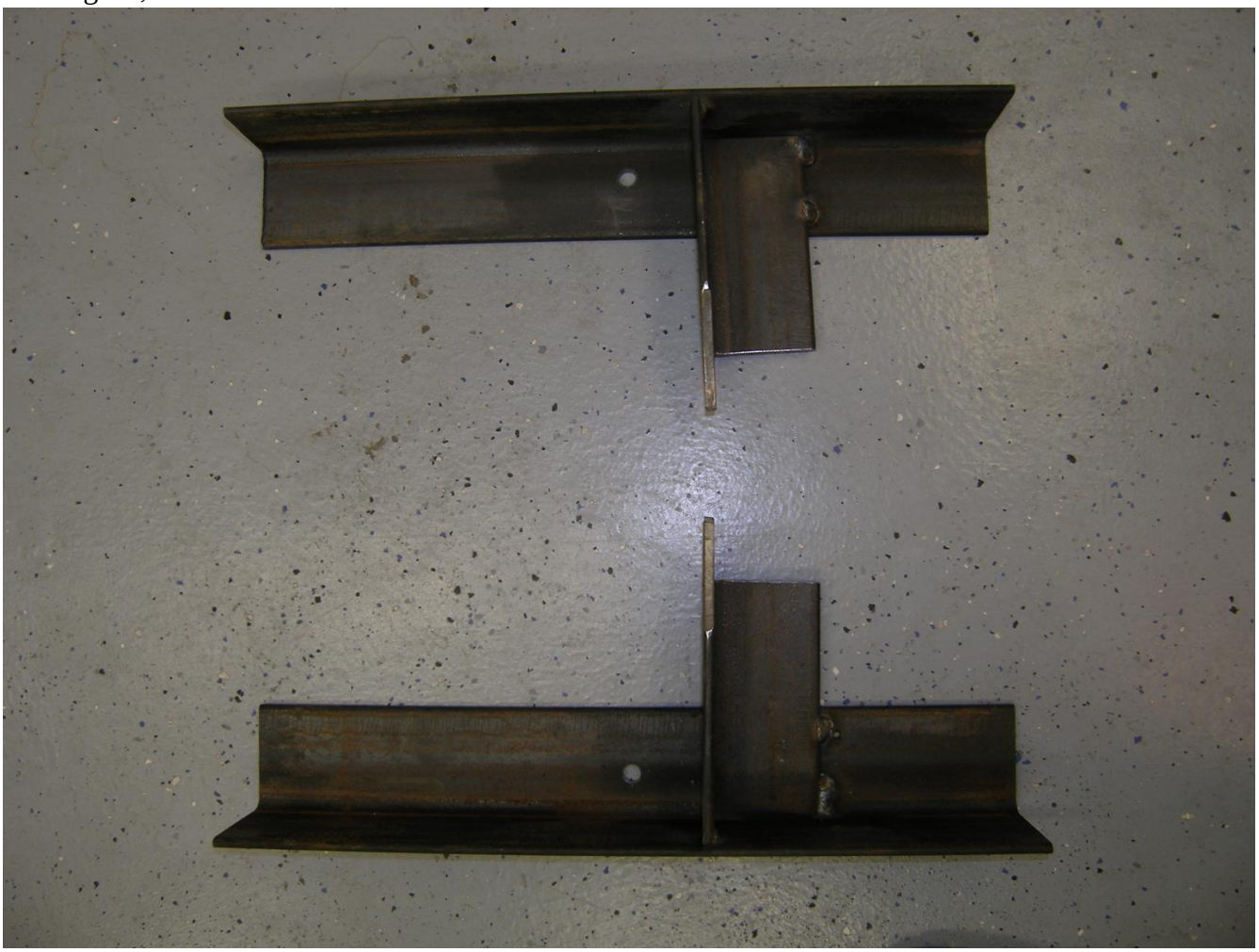


Figure 6 – 2 The motor mount parts. The long base plate (2 each), and the shorter arms (2 each)

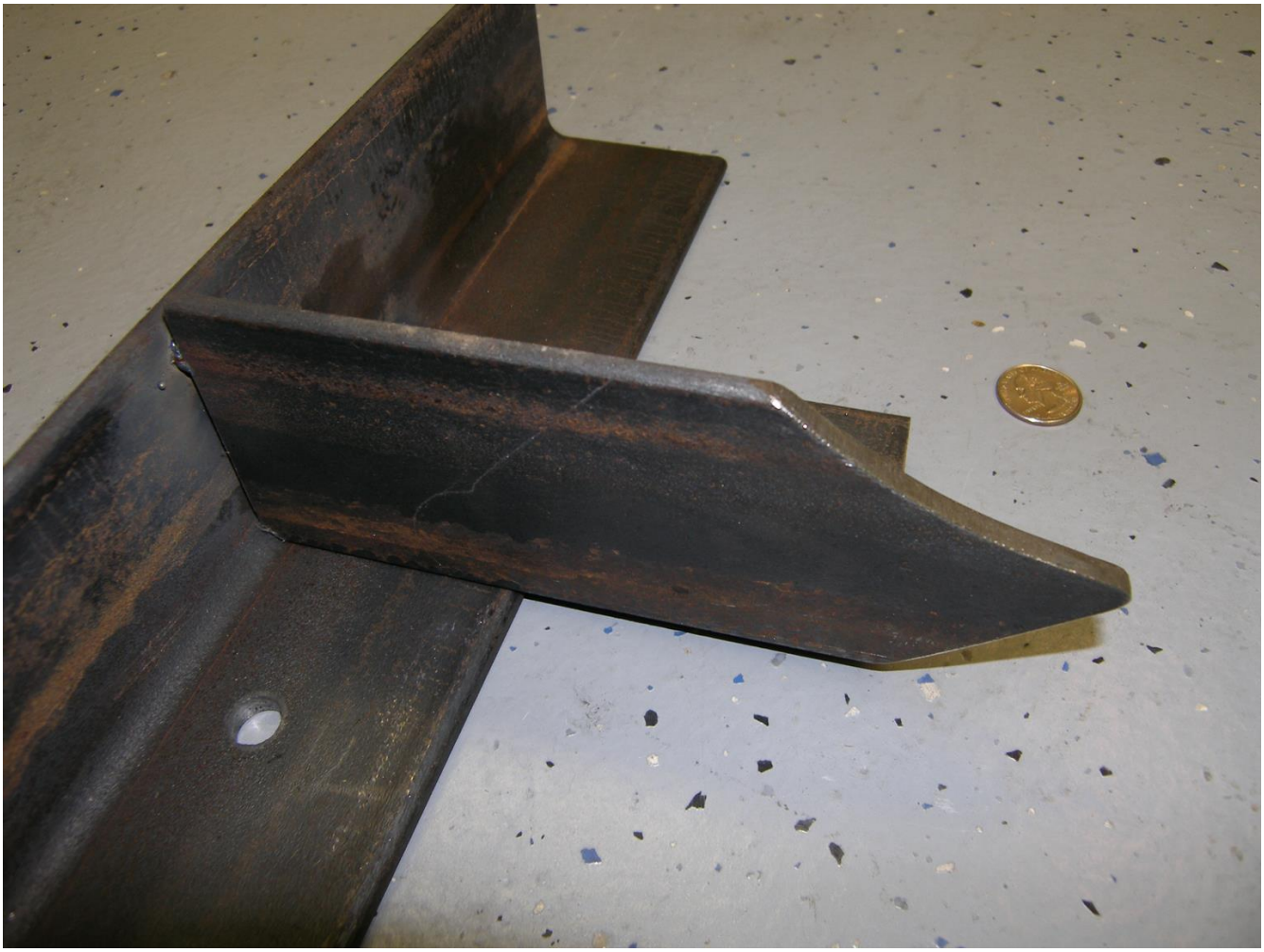


Figure 6 – 3 How the base plate and arm will come together (I think that's Mike's quarter).

When the new motor mounts are finished, one end of each arm will be welded to its corresponding base plate. The other end of each arm will extend outward to the electric motor and will be bolted to the corresponding electric motor tabs. Completing the motor mounts will provide the two remaining points of the three required to define the position of the motor.

We cut metal.

We used the following tools: A metal cutting horizontal band saw (or a 12" chop saw will do) and a 3" handheld electric grinder. Include also a 1/2" electric drill (corded) plus bits, clamps, a scroll (jig) saw with several metal cutting blades, and a welding machine (we used a 220-volt MIG with gas shielding).

For the stock material, we used 3" angle with 1/4" thick legs. This is a heavy and large stock material, but the size was dictated by the size of the motor tabs on the Motor Mount Assembly, which was furnished and recommended by the motor manufacture and by EVA. Essentially, we matched their material.

Locating a source for 3” angle of this size will not be a trip to the local home improvement store. Instead, try metal surplus stores or metal supply stores.

What we cut.

The “base plates” --- cut 2 each, 3” x 3” angle, 20” long

The “arms” --- 2 each required, 3” x 3” angle, about 10” long but you might want to wait until you know for sure what length you need. We say this because clamping a piece of metal in a cutting machine is much easier when you have a long piece of material to work with rather than a short piece.

Building the new base plates.

Each base plate was cut 20” long. We drilled one hole per each 20” long base plate. This hole was centered lengthwise and centered widthwise. “Widthwise” means centered on the full 3” wide face. Both left and right base plates will be identical.

We placed each base plate horizontal and lengthwise (with the truck) and resting on top of each existing Isuzu flat --- hole side down --- with the internal angle of the 3”x 3” angle looking toward the electric motor. We bolted each base plate to the forward hole of the existing flat. Eventually, we will drill-out and use the other remaining mounting hole of the flat, but, for now, we use only one bolt attachment hole. The reason --- by using only one hole allows the base plate to be rotated slightly. This option may help to correct any possible misalignment problems that might occur when we finalize the new EV motor mounts. We'll consider using this option later.

Building the new arm mounts.

We guessed that the arms will be about 10” long. The exact size of the arms will be determined when we shape or design the arms. Shaping an arm to fit a motor tab can be done any way you choose. You might just guess, or you might make a pattern. Either way is OK, provided that you provide enough material around the to-be-drilled bolt holes. These bolt holes will be through the motor tabs and through the motor mount arms, this about ½ “ of steel. Consider also to provide enough weld surfaces between the arms and the base plates. This will allow for a solidly welded motor mount.

Pardon us, but we admit that our arm design is kinda dumb. We didn't need to cut a concave line in the arm. The concave line was meant to follow the contour of the motor --- but this has no consequence. Just make it easy and straight forward --- our suggestion.

We also suggest a way to address this design problem --- make a paper pattern. I have used this method many times and for many reasons. It works.

Making a pattern.

It's much easier solving your design ideas while cutting paper then doing the same cutting metal. So, if you choose, get out your paper and scissors. We used torn apart manila folders for pattern material because it was handy --- but any heavy weight paper stock would do. Add sticky tape or maybe a stapler to your tool list.

From the pattern material, cut a piece that is 3” wide and about 10” long. This resembles one face of the 3” x 3” arm. Now position this 3” by 10” piece of heavy paper in the same location as you might anticipate an arm will take --- that is, the paper would reach from the inside angle of the base plate to the motor tab. Cut off the excess paper at the motor tab, keeping in mind that we need enough material for a bolt to pass through. While this is being done, the paper pattern should at right angles, or nearly so, to the base plate. Cut the paper as necessary.

Note this --- the fit of the arm-to-baseplate does not have to be perfect. The arm will eventually be welded to the base plate and nominal gaps are allowed (loose fits allow increased flow and penetration of the weld material). When you're satisfied, then the pattern is done.

We suggest that you make your design of the arms as simple as possible, this makes the cuts in the metal as simple as possible.

Mirror images.

Yes --- the left and right arms will be mirror images of each other --- they should be exactly the same, except reversed.

No welding yet --- This is how we progressed through the building process..

We make a “dry run” with clamps and bolts.

Assemble all the new motor mount parts in place. The base plates should be bolted to the Isuzu flats (one bolt per side).

The next thing to do is to clamp the arms to the motor tabs while holding the arms in position against the base plates

After doing this, clamp the arms to the base plates. Re-adjust all the parts so that all the parts fit and are happy --- no stress. Double check to see if the motor is straight down the middle (your eye). The arms should be 90 degrees with the base plates (or very close). Contact between tab and arm must be 100%. in all cases.

This is the time that you might make a slight rotation of the base plates. Remember the base plates are held in place by only one bolt. Adjustment (rotation) of the base plates could happen now to allow for that 90-degree angle between base plates and arms (your eye).

Under no circumstance do we want the motor, or the mounts, to be under any preformed stress. No forcing allowed. Make everybody happy --- and, above all --- ACYWR.

Here are a few pictures.

Figure 6 - 4 Temporary assembling of the motor mounts to the motor tabs..

Note the one bolt holding the base plate to the Isuzu flat. Only later will we drill out and install the second and remaining bolt through the base plate to the Isuzu flat.

The left C-clamp holds the motor mount arm against the base plate. The right C-clamp holds the arm against the Motor Mount tab. The Motor Mount tab is pre-welded to the motor strap at the factory. The Motor Mount Assembly strap (around the motor) and foot tab are made of 1/4” thick by 2”wide steel.

As shown in this photo and other photos, the motor is wrapped with plastic and taped to prevent particles from entering the motor. The red electric wire coming from the motor is the temperature monitor wire built into the motor's frame at the factory. We will later duct this wire to the cabin instrument panel (the instrument cluster) to operate an “over temperature” light.

Figure 6 – 5 Detail of the temporary clamps.

In the figure, note that the left C-clamp holds the arm to the motor tab and the right C-clamp holds the arm to the face plate. Note also the close matching contact that the arm has with the two faces of the base plate angle. This will yield a very strong weld between the base plate and the arm.

The next step is to make one final check of the motor mounts before the welding process.

The next figure shows all of the C-clamps in place.

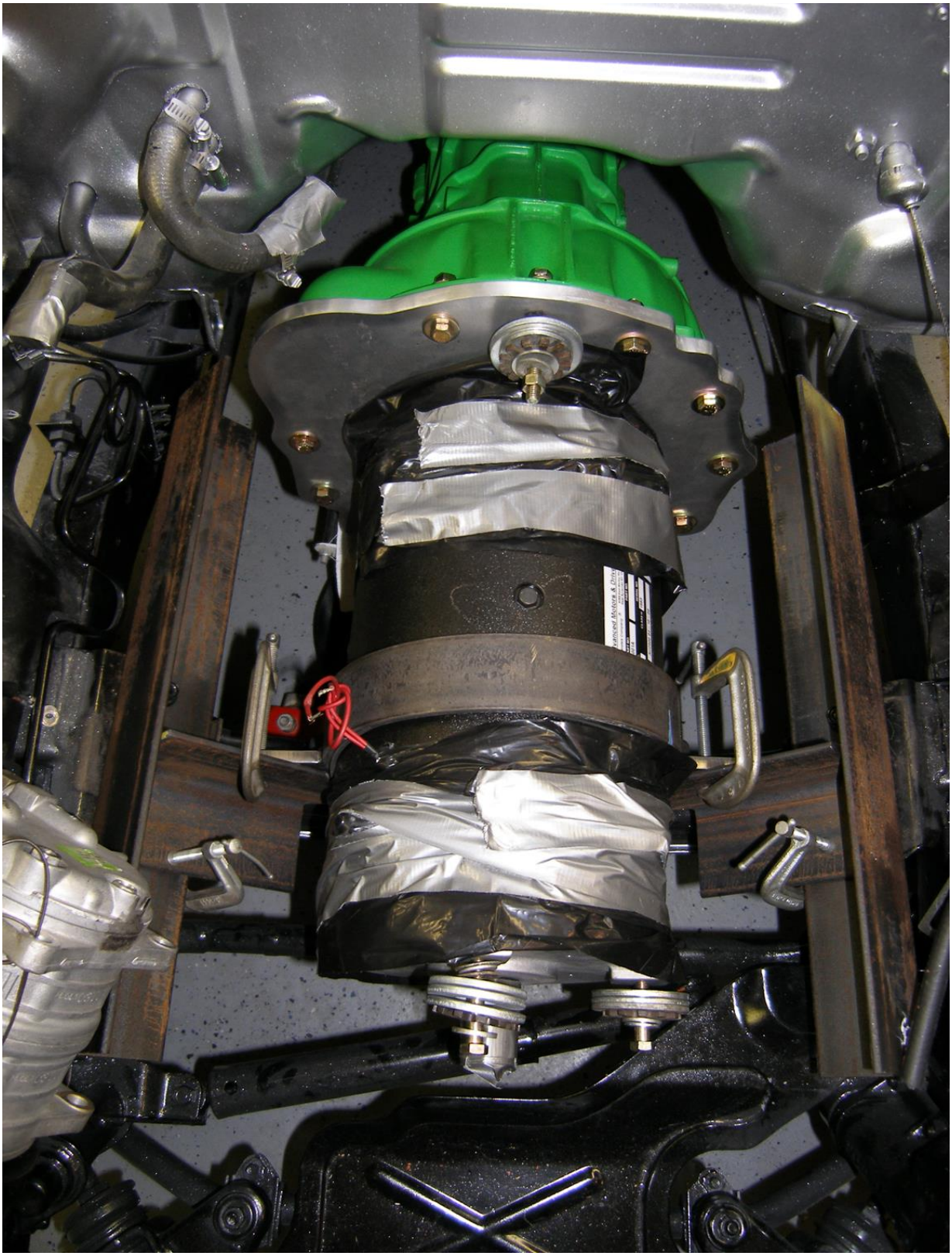


Figure 6 – 6 Complete temporary installation of the motor mounts

Now, just for the fun of it. ---

Disconnect the bolts (one per side) that holds the base plates of the new motor mounts to the existing

flats of the Isuzu chassis (one per side). Leave all the C-clamps in place EXCEPT for the C-clamps that hold the arms to the motor tabs. Remove these clamps and lift out the assembled motor mounts.

If this happens --- then put everything back.

Re-clamp and re-bolt. Make sure that everything lines up as before and all the bolts and clamps are back and tight, and there is solid contact between the motor tabs and arms. Reaffirm that the arms are reasonably close to being at right angles to the base plate. Rotate the base plates, if necessary. Stand back and reassure yourself that everything looks OK. As always --- ACYWR.

Spot welding and drilling in place, the process.

First, wrap the motor. Use plastic bags. Tape the bags in place. Don't tape directly to the motor body, as mastic is difficult to remove. Wrapping will avoid weld spatter or drill chips from entering the motor.

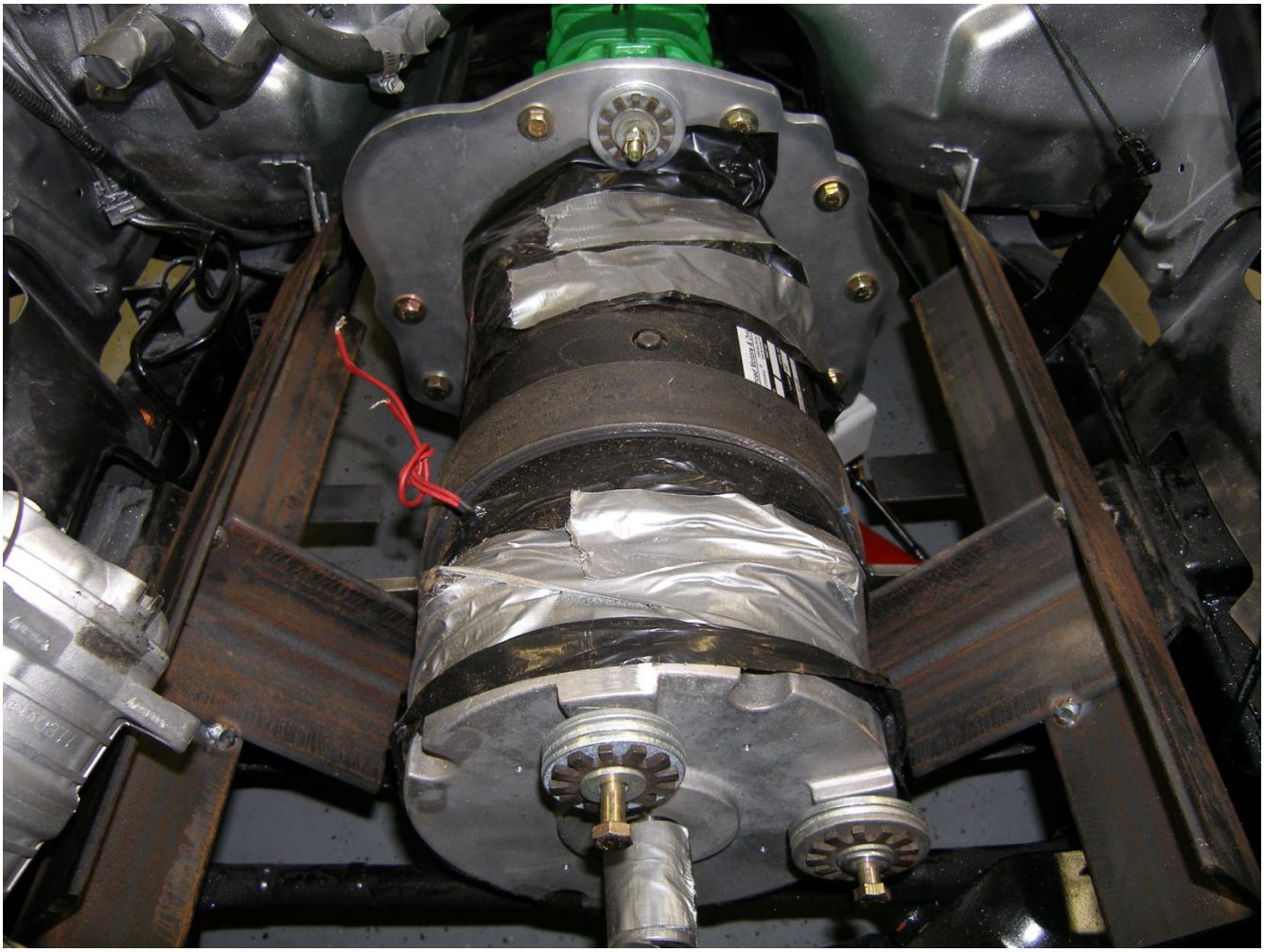


Figure 6 – 7 The motor shown wrapped to prevent foreign matter from entering the motor vents.

We can now spot weld in place and, if possible, drill bolt holes where you can and install bolts.

If you can't drill or spot weld in place, then mark your drill locations, keep the necessary clamps in place, and remove the assembled motor mounts from the motor bay and finish drilling and spot welding as required.

This is exactly the reason why we tested to see if the assembled motor mounts could actually be removed --- we assume nothing.

Figure 6 – 8 Detail of spot welding in place.

We spot weld because we can remove the welds if necessary. Removing the spot welds is just a grinding process and is reasonably easy. We proceed with this process until we're satisfied with the results. When satisfied with the mount geometry, we will then finish weld the assembled motor mounts.

During this final welding, the original spot welds will be consumed by the finish welding process.

Figure 6 – 9 Spot welds in place plus one bolt shown from base plate to Isuzu motor mount flat.

Given that we are satisfied with the motor mounts, the next step would be to drill the last hole to secure the base plates of the motor mounts to the Isuzu chassis. We do have the old Isuzu motor mounts, so we can determine where the remaining hole should be --- almost. The only change would be if the base plates were rotated. Because of this possibility, we need to locate the hole by actually marking its location. This is going to be a tight job. The other solution is to make this second hole a little bit larger to compensate for any misalignment. What we probably will do is a little bit of both.

As I remember, we shortened a pencil so that the extra pencil length would not interfere with the close space involved under the truck and through the suspension components. We were able to mark, in some reasonable fashion, the location of each motor mount hole. We removed the new mounts and checked our marks with the old Isuzu mounts. Everything seemed to work according to our satisfaction, so we drilled them out. Everything went well.

Finish welding and drilling.

Figure 6 – 10 Detail of the complete weld and bolt placement. .

The dark bolt head to the left is the last bolt attaching the base plate to the old Isuzu chassis flat.

The bright and larger bolt to the right is the bolt that attaches the motor tab to the new motor mount arm. Your decision here is where do you drill the hole so that there will be a sufficient amount of material around the bolt hole in the motor mount and also around the bolt hole in the motor tab. As it turned out, the center of the 3" wide leg of the angle iron was reasonably centered in the center of the motor tab. Again, everything worked.

The next figure shows the final placement and installation of the three critical bolts for the EV motor mounts.

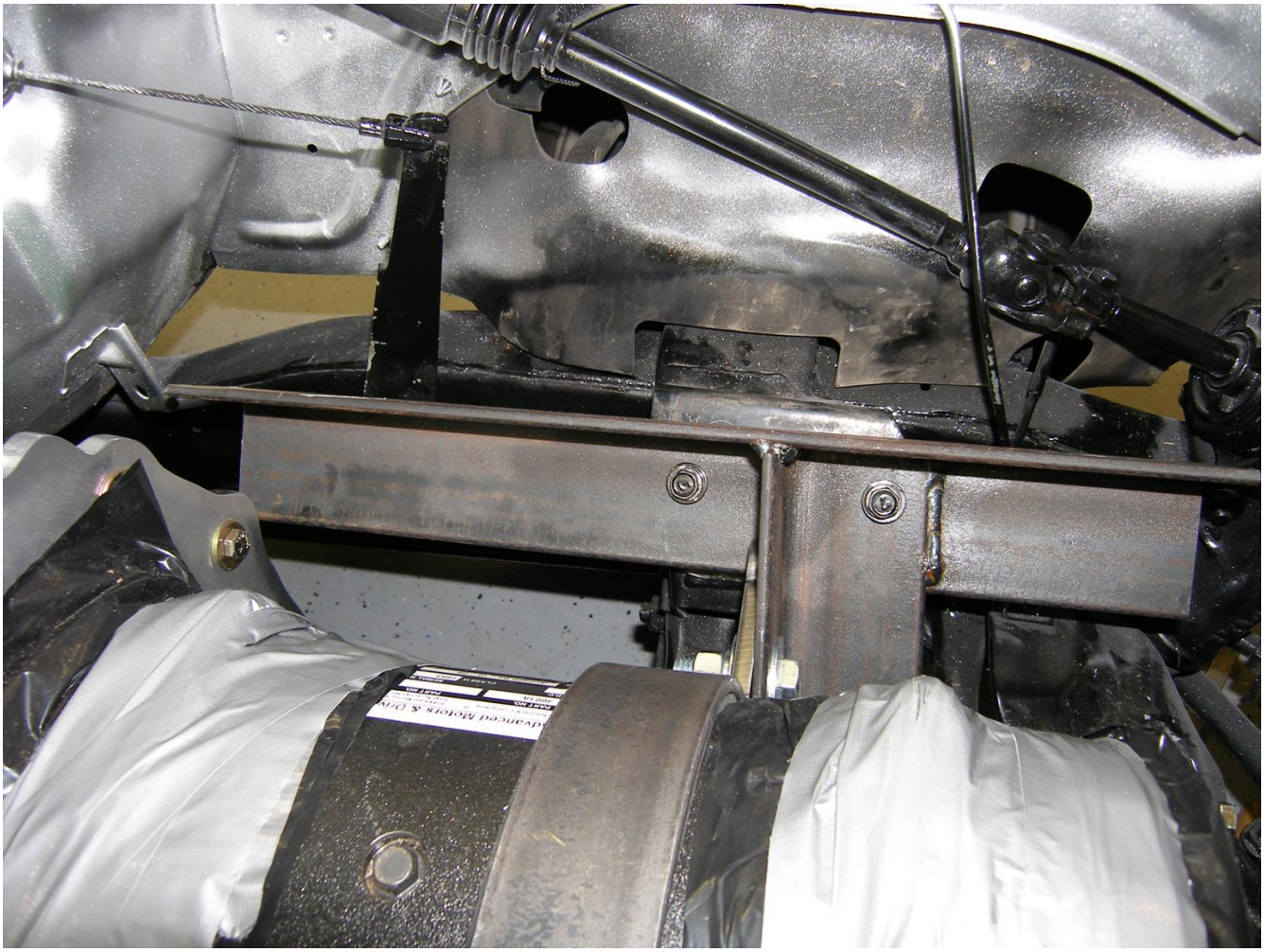


Figure 6 – 11 Showing bolts in place from base plate to existing Isuzu flat plus the lower motor tab bolt.

The next figure shows the final overall configuration of the EV motor mounts and the final positioning of the EV motor in “set” position --- that is, the EV motor is in the exact position as was the old gas motor of the Isuzu. We are done.

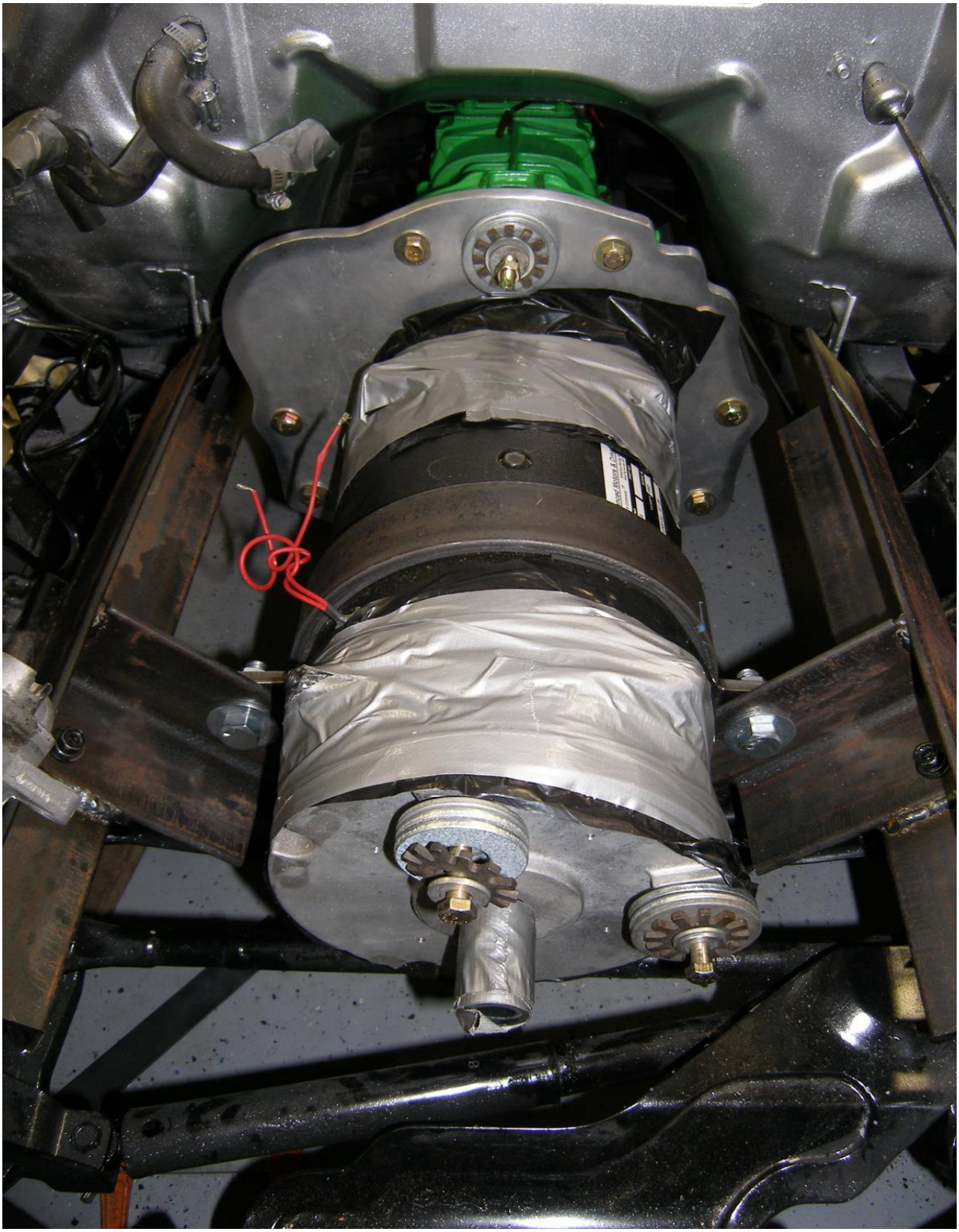


Figure 6 – 12 The final bolted and welded configuration of the motor mounts and motor.

PART SEVEN --- PLACING THE MAJOR ELECTRICS

What's next --- the major electrics.

We got'm --- the major electrics --- and the minor electrics --- we introduce them now.

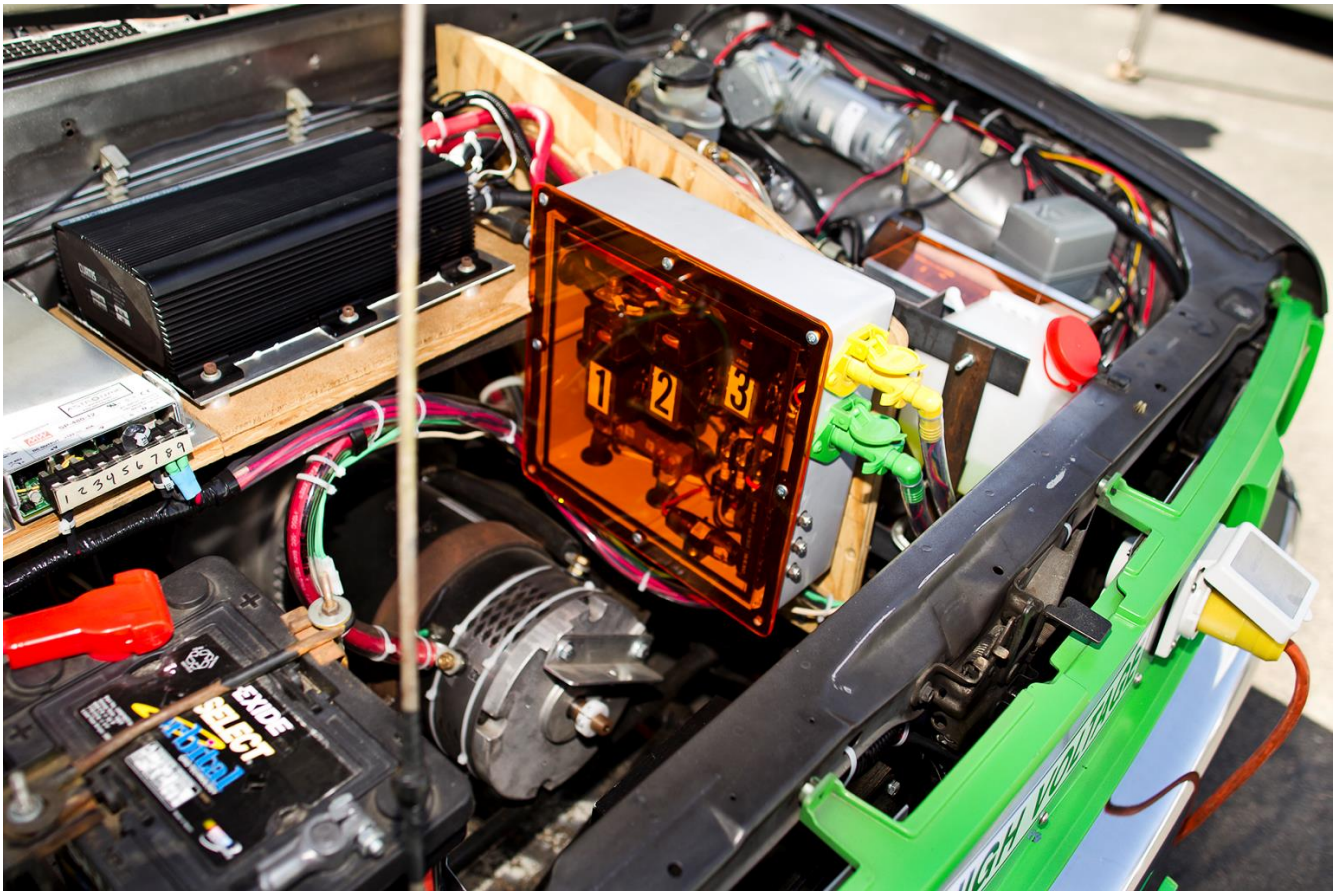


Figure 7 – 1 The complete and assembled daily driver. (SMUD event 2012)

The Curtis Controller.

The Curtis Controller is the big black box, upper left in Figure 7 - 1 --- it controls the 500 amps of power generated by the battery source and, obviously, requires a lot of cooling. Besides being black for radiation purposes, it has cooling fins on top and all around and a built-in fan (bottom) plus an aluminum heat sink base. The Curtis Controller is priced out at $1,495 (2008 dollars). More information can be obtained at www.curtisinstruments.com . The model number is: No. 1231C-8601. We don't know what's inside, but its presence is required for the MYEV2 to work. We assign it to be mounted in the most prominent spot, that is, under the hood, front and center, above the motor.

The Astrodyne Charger.

The next in line is the Astrodyne Charger --- it's the aluminum shinny box, upper far left in Figure 7 –

1. We located it next to the Curtis Controller, but to the left side of the motor bay (the passenger side). This location is on the same side as the Isuzu's 12-volt battery. Why? Because it charges the 12-volt battery. The Astrodyne Charger trickles off enough power from the big power source to charge the 12 volt battery that, in turn, powers everything else that requires 12 volt power. The industry refers to this type of equipment as a DC – DC Converter. The Astrodyne Charger sells for about $280 (2008 dollars). More information from www.astrodyne.com. The Model Number is SP-480P-12.

The Contactors.

These are just very large relays. They are located in the amber box, Figure 7 – 1, and are labeled "1", "2", and "3". They do the same job as smaller relays but are made to handle large power (high voltage and amperage). For our needs, we will use three of these Contactors. They are Albright Contactors, SW-200. They come in at $150 each (2008 prices). For more information, reference Electric Vehicles of America, Inc. (EVA), located in New Hampshire, Zip: 03894. Website: www.evamerica.com EMAIL: EVAmerica@aol.com.

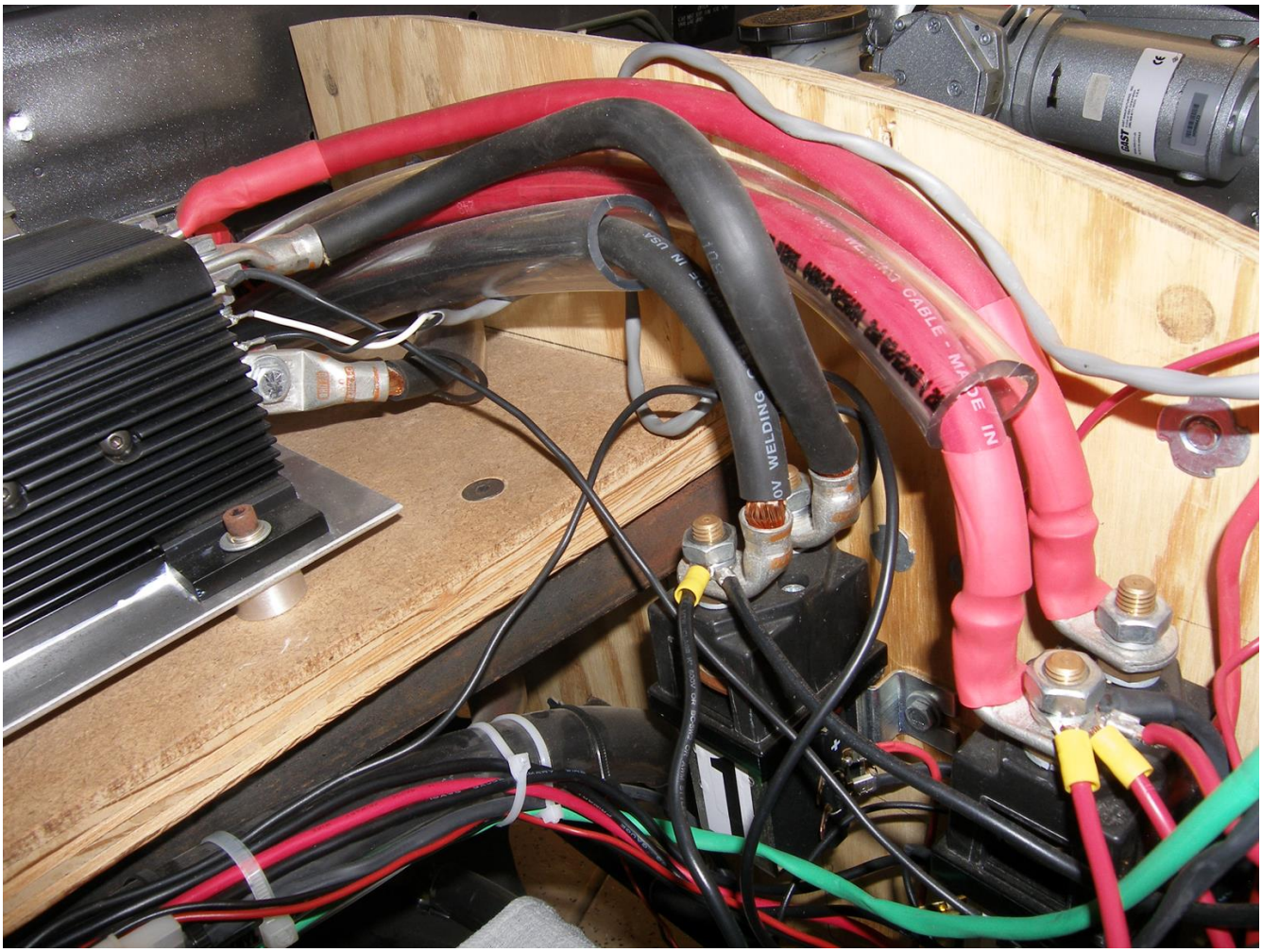


Figure 7 – 2 The "big black" and the " big red " cables.

The heavy 2/0 AWG cables.

Of the remaining items that are not necessarily large but still difficult to handle, are the 2/0 AWG

cables. EVA suggests that we use 2/0 AWG cables for all battery applications or connections. For your information (and ours), the " AWG" part stands for American Wire Gauge. The "2/0" part stands for the size of the metal conduit that actually passes the electric current. Size of the insulating sheath that covers the current carrying conduit is not considered. The conduit part, in most cases, will be either copper or aluminum. In our case, using 2/0 AWG cable, the metal conduit is about the size of a ball point pen. That's about 3/8" diameter. That's big.

The electric industry uses a shortcut for designating conduit wire of this larger size. The "2/0" is a shortcut for writing out "00" . Larger or heavier cables may be designated as 3/0 or 000, another as 4/0 or 0000, even larger as 5/0 or 00000. You can see why the electric industry chose to use the "/ " shortcut rather than using a lot of zeros.

Before we leave this topic, however, please note that this topic can easily become very confusing.

One overall truth, however, remains. And that is ---

The larger the number, the smaller the electric wire --- smile --- you can take that to the bank.

For example, if you're looking for a 50-foot extension cord for your electric weed eater, choose a 12 AWG cord over a 16 AWG. The 12 AWG will have a larger electric conduit and will be able to carry more current over that distance. Better yet, choose a 10 AWG. However, a 10 AWG will be heavier and bulkier to haul around your garden. Take your pick.

In our case, 2/0 AWG welding cable will be used in all of our battery related applications. The fact that we use welding cable makes a big difference. It's flexible. The conduit of welding cable is made up of many, maybe 100's, of parallel strands of really small diameter wire. That's the secret --- instead of a single very large wire --- many small ones. This makes the welding cable much more pliable and easier to handle or bend around corners --- but it's still not a "piece of string" --- as the overall outside diameter of our 2/0 AWG cable (including insulated cover) is about 5/8" in diameter.

For what we need, EVA sells 2/0 AWG welding cable for $4.00 per foot. We need about 50 feet of black cable and about 25 feet of red. That's about $300 for the total. We will use this cable to connect all the individual batteries together --- all in series --- and to deliver this power to the Curtis Controller, which we plan to locate up front.

Placing the Electrical Parts.

How do we do this? We don't know --- but we're learning.

First off, we can see how other people have solved this problem. As before, we called up www.evalbum.com..

We found out that the " people of the world" were "all over the map". We did, however, satisfy our curiosity and we did corroborate our own thoughts about using tables (flat surfaces) to fasten electrical parts to instead of to the entire car body. We found that some people did use tables, but a lot of the EV builders hung electrical boxes on firewalls or fender wells or worse. For us, that was frightening. We wanted "understandable" in one spot. Our consensus was "tables", no doubt about it.

Figure 7 – 3 This is very nearly what the EV bay looked like before the arrival of our “tables” and the introduction of the electrical “parts”.

Our view of “tables” revolved around only two words, either “vertical” or “horizontal”. Either one would do the job. It was just like setting the dinner table or like playing Monopoly or Chess or simply moving Checkers around the game board. It turned out to be more complicated than that. Some parts were “hot”, some were “cold”, some were “scary” and some were just belligerent.

We divide out thoughts into two parts, horizontal or vertical.

The horizontal table.

At first cut, we decided to put all the electrical parts on top of a horizontal table in the bay. It would be in the bay and above the motor. This certainly makes sense and this thought was shared by many of our “album” friends of the world. We could put almost everything together and in a form that would be, almost, intuitively understandable as to function. The table would have to be large. We laid out the parts. It could be done, but we had to reconsider. We forgot the wiring. The parts had to be

connected with wires, the table size expanded and, theoretically, it would overflow the Isuzu motor bay. The horizontal table was too big. Call it what you may, but we did not want this to happen. We wanted the motor to be seen, not to be hidden under a table. The motor was the symbolic essence of our car --- it was our prime mover. We wanted it seen. Nada on the horizontal table.

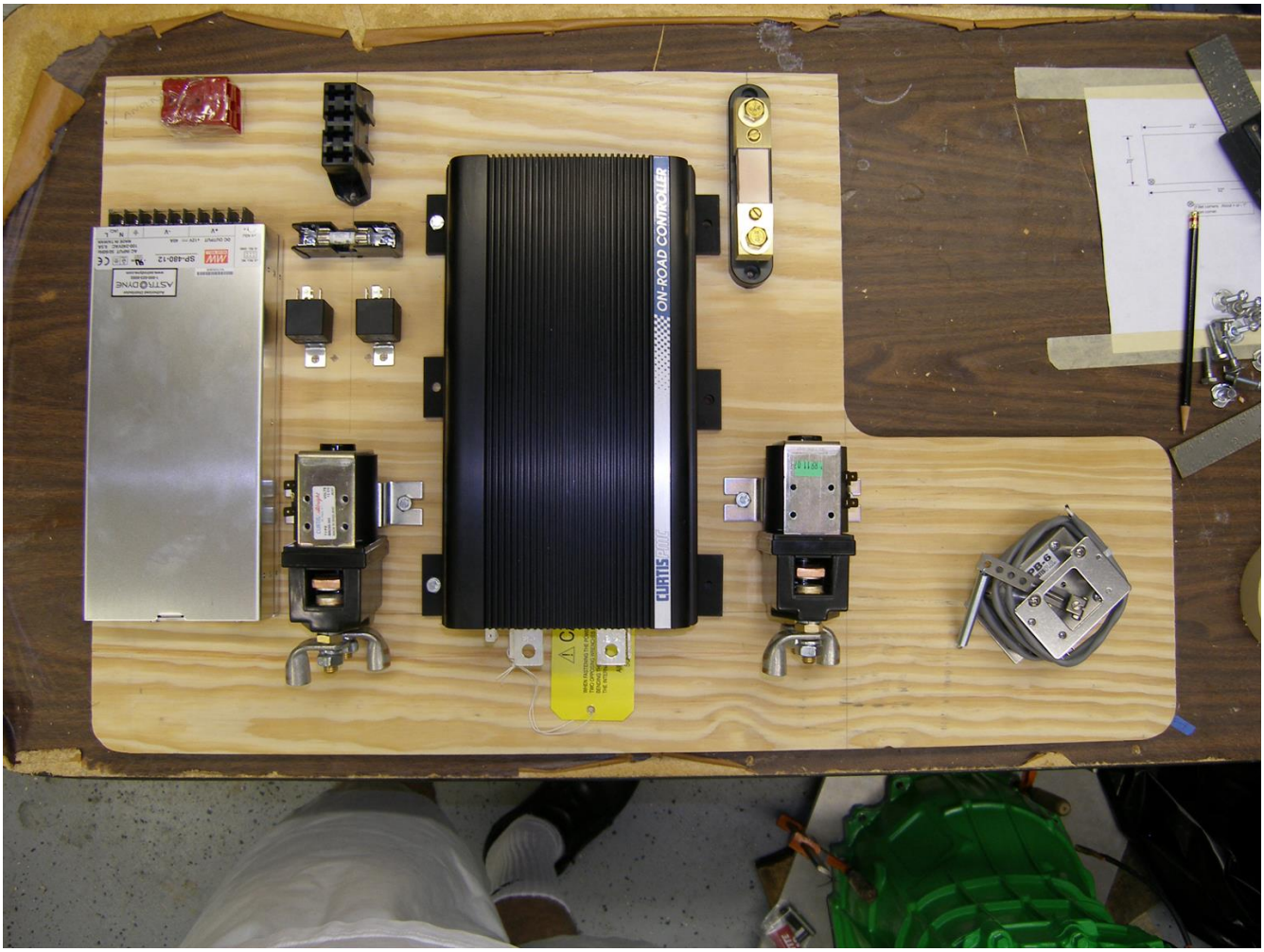


Figure 7 – 4 It looks simple --- our first cut at “tables”.

In our view, it was like playing Monopoly or Chess or simply moving Checkers around the game board. It turned out to be more complicated than that. Some parts were “hot”, some were “cold ”, some were “scary” and some were just belligerent.

Figure 7 – 5 We cut out a sexy looking vertical table that looked like it would fit under the Isuzu hood.

The vertical table and the “final answer”.

In considering a vertical table, we actually spent several of those precious early morning “Sweet Spots” just hashing out this problem. We experimented ; we have pictures.

We continued to hash things out . All of this, as you might guess, ended up in the middle --- a little bit of horizontal table and a little bit of vertical table. Another “final answer”.

We cut metal (and wood).

The vertical table that you see in Figure 7 – 5 was cobbled together from a piece of ¾ inch thick exterior plywood that was left over from the battery box (remember ?). We cut what we thought we needed and positioned the plywood, vertically. We chose to put it on the right side of the motor (looking at it from the front of the car).

Likewise, for the horizontal table, we found some 1-inch angle iron (like from an unused bed frame). It had a 1/8-inch wall thickness. We attached it to the vertical piece of plywood and ran it over, across the motor bay, horizontally, and above the motor to the other side of the motor bay. We fastened the metal angles to the Isuzu body via bolts through existing holes. We attached some more pieces of that

3/4 “ thick plywood to the angle iron and produced a narrow horizontal table. That mix of horizontal and vertical tables still exists today.

Figure 7 – 6 Here they are, the two tables and the three humans --- being proud of their work.

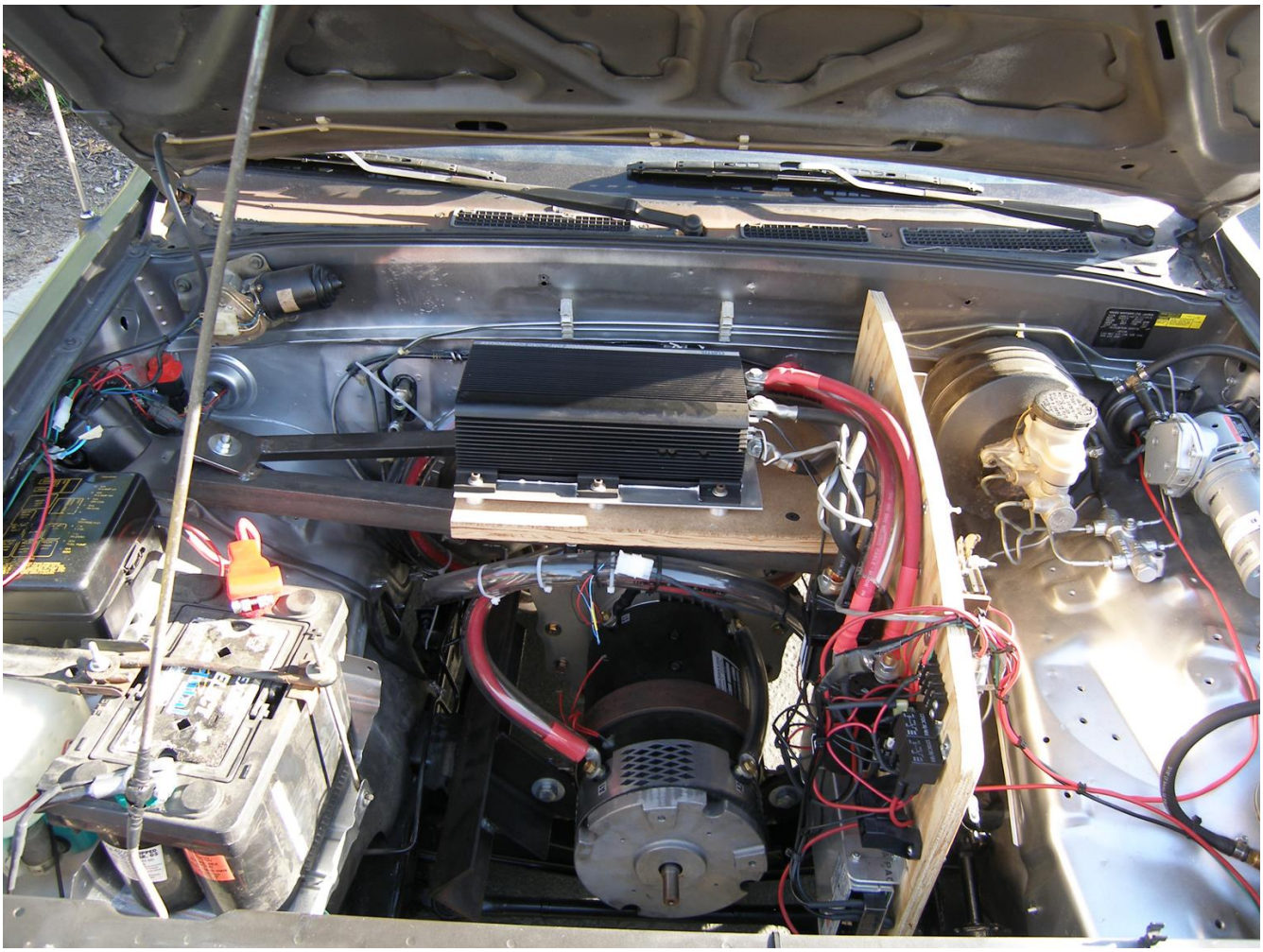


Figure 7 – 7 An early view of our tables.

Figure 7 – 7 is an early view of the vertical and horizontal table configuration. Both tables are fixed in the motor bay by the use of original Isuzu mounting holes. The vertical table is connected to the new EV motor mounts and the motor mounts are connected to the original Isuzu motor mount “flats”. The horizontal table is, in turn, fastened to the vertical table and the triangular frame is connected the one hole on the left (passenger) side of the EV.

We tried to use existing attachment holes so as to not modify the donor car. This was one of our initial concepts (one of our original “Keys”) but , later, we realized that this was not really needed. In no way were we going to turn around and return the Isuzu to its original condition.

Our main concern was to make the conversion as easy as possible for others to follow. So the least amount of drilling and other modification to the donor car was at the top of our list .

We, and others, will survive small amounts of modifications.

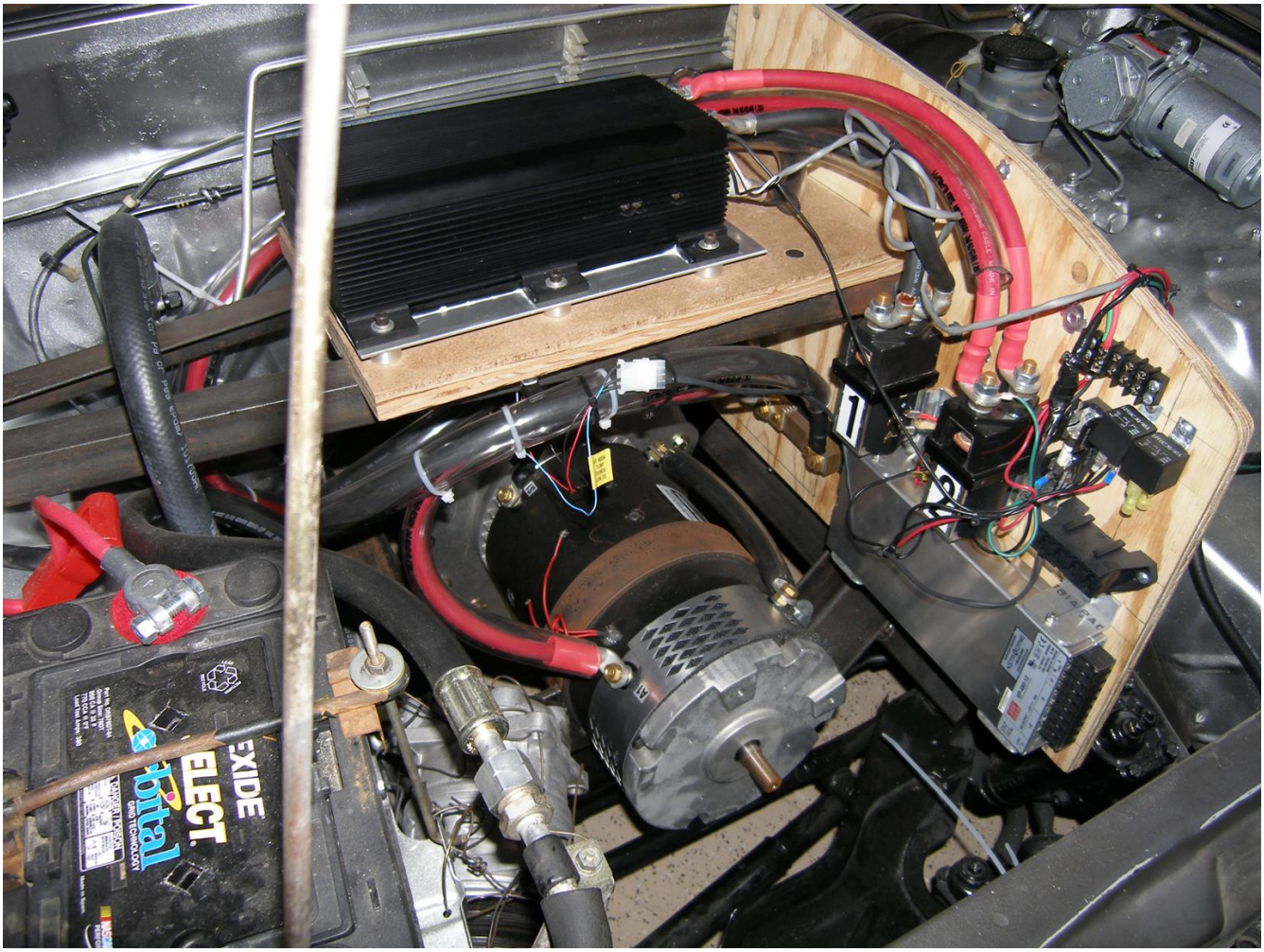


Figure 7 – 8 A somewhat later version of our tables.

We place electrical parts on our new tables.

We were able to put the Curtis Controller and the Astrodyne where we initially wanted them --- in front and over the motor. No problem. They fit just fine on top of the horizontal table. The 2/0 cables threaded through the chassis and came up right in line with the Curtis Controller. We would later learn that the cables were going to be the source of our largest problem. We carried on like this until we finally had to stop. The 2/0 cables were just too strong of an influence. We had to compromise our planned layout.

We pause for cables.

We couldn't put it off any longer, the cable problem had to be solved. The 2/0 cables connected all the batteries together and provided the power to the motor. Because of this power carrying requirement, the cables were necessarily thick, bulky, and just hard to handle. They were, however, the best quality cables we could find. They resembled welding cable, flexible for their size. Considering that the stranded copper conduit inside the cables was about ¼ inch in diameter and the outside was about 5/8 “ in diameter cables still represented a moderately amount of difficulty to work with. It was a chore.

All connections had to be non-solder (solder might melt). Only metal to metal crimped connections were allowed. The tool necessary to cut the cable and crimp the connectors had handles about 3 feet long. The handles had to be long enough generate the considerable amount of "arm" power to do the job of cutting and crimping.

After all the cable interconnections inside the battery box were complete, we ducted a line of cable (one red and one black) from the back of the EV to the front of the EV. But before making any connections, we threaded all of the "outside" cables (outside the battery box) through a clear plastic tube, 1 ½ inch diameter. This was for safety reasons, to prevent fraying or cutting of the insulating outer covering of the cable against the chassis or other material.

Back to Electrical Parts.

The Curtis Converter was the only two electrical unit to be mounted on the horizontal panel. All other parts and pieces will be positioned on the vertical panel. At this time, the Astrodyne Charge still remained on the vertical table. We tried to lay out the parts in a way that made sense. We put the three contactors upper left on the vertical panel. Below and to the right of the contactors we temporarily fastened the fuses, the three small relays and the remaining parts. We tried to follow what made sense and followed our "Keys" of compartmentalizing function.

My gripe.

When we started to work on this project, we quickly realized that there is no overall plan --- no overall wiring diagram that brings all the parts together. You will find that each individual electrical part has it own wiring diagram (and drafting style). My gripe is that we want it together. That's the gripe. But then, on the other hand, Mike has no problem with this. Mike seems to integrate the individual parts very well --- all in his head, not me. So, for my part, I'll just go along for the ride and try to pull everything together when we near the finish line (this will ultimately be the Wiring Diagram).

Chaos was creeping .

We mount the parts, place the 2/0 cable, and connect the various lengths of smaller wire. We were making good progress when we realized that, behind us, was the makings of a very large ball of different colored electrical wire. Chaos was creeping.

Let me explain. Time was getting short. No attention was being made about cutting the individual connecting wires to any specified length. We were getting close to completing our project and that was the only thing on our minds. We knew that parts were sure to be rearranged in the future. Also, our thoughts were certain to change, so wire length would certainly change as well. So chaos kept on growing.

We had no idea – as our interest was so pegged upon getting the EV to move on its own, that everything else was not even close to our aware zone.

Getting close.

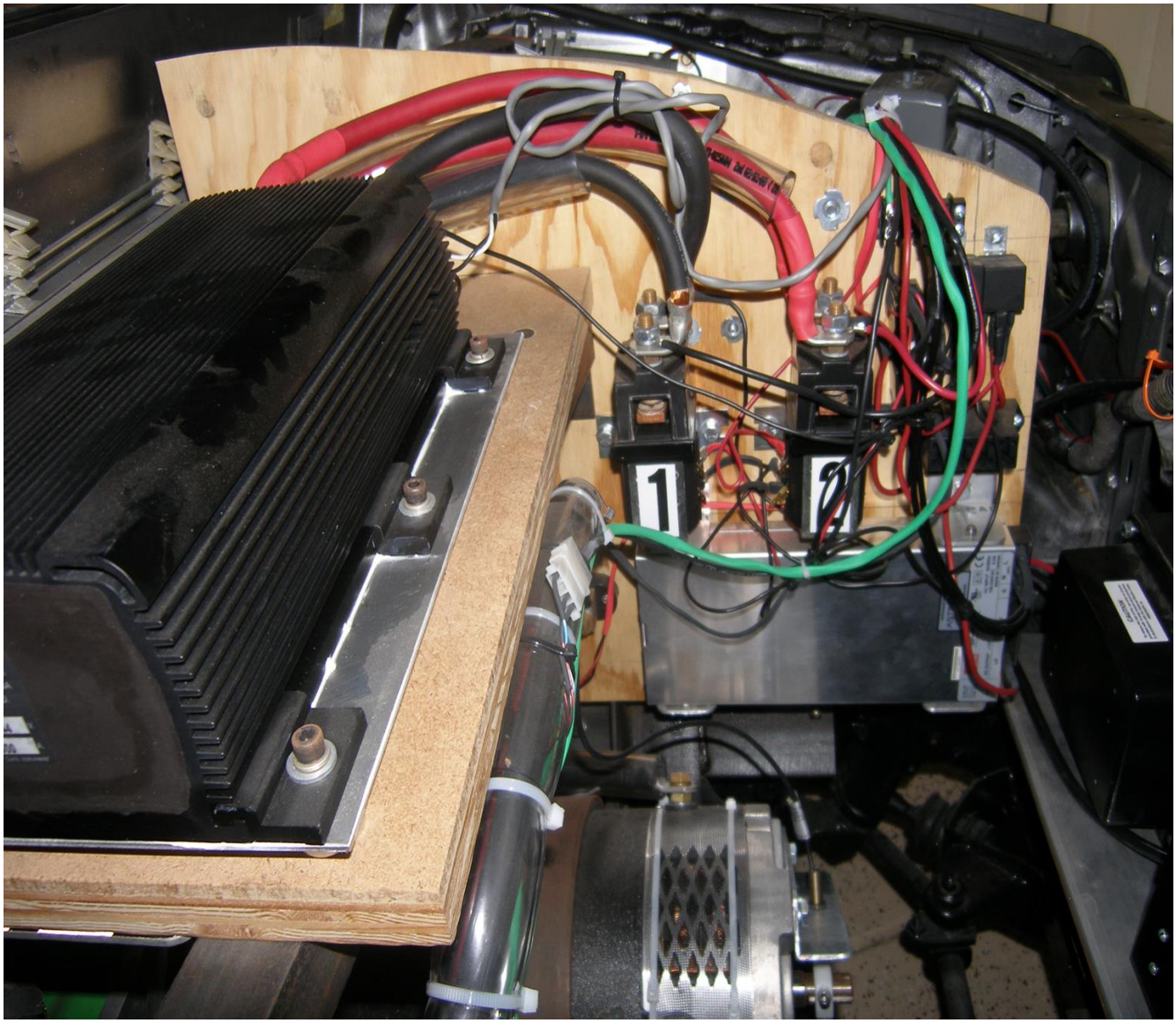


Figure 7 – 9 Another view of our early thoughts on parts configuration.

What was about to come.

Color Coding Chaos.

Another complication, we couldn't afford to color code the wire (we tried). We were using automotive wire. There was only three or four colors to choose from --- which would later get mixed up anyway. Chaotic, it was.

Considering all of this, we felt that, later, especially, there was going to be a real critical need to identify the hundreds of wires. We looked online for answers, but nothing. We visited electronic shops and surplus stores, also nothing. We did find some identifying tags, but they were too big and much too expensive --- we needed hundreds. We found our answer in our garage. We had them in our

hands.

The ZIP Tie Explosion.

ZIP ties --- what more can I say. Ever look really close at a ZIP tie ? Well, we haven't either. Look again. On the back of the "clicker" part, there's a flat spot. It's just big enough to write a skinny three-digit number --- with a really fine tipped flow pen (use permanent ink). Another good thing, when the tale of the ZIP tie is clipped off, the tie heads are small enough not to interfere with surrounding wires. We're happy with our cheap discovery --- it's creativity 101.

We're getting close --- but disaster is about to happen.

Mike sold his house. The shop has to move --- and the EV doesn't move yet.

But all is not lost. We winch the EV on top of an auto transporter and, 30 miles later, roll it, backwards, down my slanted driveway and into my garage. We continue.

It's close.

It took a few more "Sweet spots" at the EV's new home in my garage until we were finally ready to turn the key. Not so. We were faced with a minor dilemma.

EVA had sent us a speed control unit which we had temporarily attached to the vertical table. This positioning was somewhat in line with the existing Isuzu throttle control cable, but it did have a slow bend going to the unit. We could live with the slow bend, but we couldn't live with the fact that we couldn't connect the two together. The speed control rod and the Isuzu throttle cable were a "no-go". There was no way to make this simple connection. We were hobbled by a simple mechanical part. Yes, we were anxious to turn the key, but no --- it's the simple things that always seem to be the baffling ones. So we used our past experience to solve this problem. It was either use a wire coat hanger or a paper clip. We opted for the latter. We bent the clip to match the input rod of the motor's speed controller to the Isuzu's operating cable, everything seemed to be OK for GO.

Are you sure? Are you sure? Are you sure? Are you sure?

These were my questions to Mike. We relied one hundred percent on Mikes knowledge of the circuits. I had no way of backing up his circuit wiring knowledge. For both of us --- it was a leap of faith.

We were nothing but anxious. This was the culmination of weeks (months) of checking and rechecking. But this time, we started to write things down on paper. Even Mike was having trouble keeping everything in his head. I penciled in the wiring and connections as Mike dictated the information. We did this over and over again. We would use different colors of highlighter flow pens to designate each pass of checking and rechecking. It was color on color, scribble on scribble, coffee stains on coffee stains. We could not make a mistake. A mistake could mean replacing thousands of dollars' worth of parts. No mistakes, ever. But now, curiously enough, we were almost put down --- but, miraculously, we were saved by that bent paper clip. What can you say --- we move on. We wanted no "drama" of any sort --- which primarily means --- no popping noises --- no sizzling sounds --- certainly, no smoking of any kind. None. We go forward completely on Mike's knowledge.

With a fading memory, this is what happened …. a few years ago …. It went something like this ….

….....

“….....the garage door was open …. it was Autumn ..... cold and windy. Leaves swirled over the driveway. Mike was behind the steering wheel; I was in front. We had removed the hood --- so both of us could look for smoke. We were sure that the wiring was correct …. confident. Mike could see me ..... I stood near the right front fender .... I watched for smoke … as he would do also, but I was closer ..... Mike was behind the wheel ..... he turned the key. Nothing happened ..... no smoke ..... so he pressed the “gas” peddle ..... just a little bit ..... still no smoke ..... I looked down and saw the driveway leaves disappear. I thought, that was strange. They were underneath the EV ..... that's all that I can remember ..... it was just inches ..... and the leaves ..... that's what I can remember ..... “our baby” was born …..... ”

….....

After this experience, I sat down, closed my eyes, felt the moment, and did the best I could to describe (type) this experience. No punctuation --- no spelling --- just what I could remember --- .

That's all I remember --- so let's move on.

Sometime later --- it became Christmas --- I don't know which Christmas, but Christmas. I know this for sure because I opened a Christmas gift. It was a painting. It was our EV. It came from my younger son's family. Chris's oldest daughter painted it and it was beautiful. Please remember, when you're wrestling with parts and purposes, and you're are trying to fit everything together, it's good to know that your family supports your efforts. My granddaughter's painting is on display on page one of our web site. We love it --- and we love our supportive families. Thank you.

Figure 7 – 10 The painting --- Our “ Baby” was born this day.

Painting by Michael Evans …

It was later --- after that "first few inches and leaves" episode, that we brought our tools together and moved the EV over to Mike's new garage --- but this time, we drove it. Mike took the wheel of the EV and I followed in my car. Mike's new garage was just a few miles further away, maybe 35 miles total. The EV had no trouble. He drove it up his slanted driveway and into his new garage, front end first.

We look back in fondness here. We had a truck bed full of batteries. They weren't covered up. Everybody could see them. Remember, we were among the first in our area to attempt to demonstrate the feasibility of using electrons to power a full-sized vehicle at freeway speeds. People here were not used to this "crazy stuff " happening. Second looks were the norm. Second looks --- comedians call them "Double Takes" --- would happen either on the road or in coffee shop parking lots. It was exhilarating. Mike and I reached for this moment. We found great satisfaction in that hard-earned success. We yearned to relive those brief few moments in my garage on that windy.

Still --- we were busy enough for that far-away-dream to begin to fade. We did have one item to remind us. We had a piece of paper. Days before that windy day, I started to scribble on a piece of paper. This was days before Mike turned the key. We were anxious and in a hurry. By myself, I was totally inadequate to document the EV's electronics. And, actually, we could care less --- all we wanted to do was to turn the key.

But now --- weeks later, we still had this piece of paper. It existence was our first attempt at documenting our efforts. Years later that same paper would see itself stored in a garage box, labeled "EV Parts" --- but for now, it was in our hands. We were ready for the next event.

PART EIGHT --- THE WIRING DIAGRAM

We drew pictures. We were driven to document our years of effort. That coffee stained scribbled on piece of paper would soon become the start of our Wiring Diagram. It's important. To us, at least, its certainly important and I would like to think that it would also be important to others who might dream of future ideas.

You can think about something, but that "thing" you are thinking about suddenly has much more meaning when you put your thoughts on paper. Draw pictures of it --- do anything that makes sense (to you). Do anything that makes your thoughts come alive. That's what we did. Certainly, we stumbled along the way --- but that's the normal circumstance of creativity. Don't be afraid of looking stupid. Just do it.

So that's what we did. We just did it. (And I'm sure that we did look stupid --- but nobody noticed us --- as no one was awake so early on Sunday mornings) We started to put things in a logical (to us) shape. We started to put that scribbled piece of paper in a " language" that people (including us) could understand.

It went like this; Mike would describe the connections and I would put his descriptions on paper --- not knowing what else was coming. The paper immediately began to get bigger. We taped additional paper together as needed. Coffee stains and all, the following was the result.

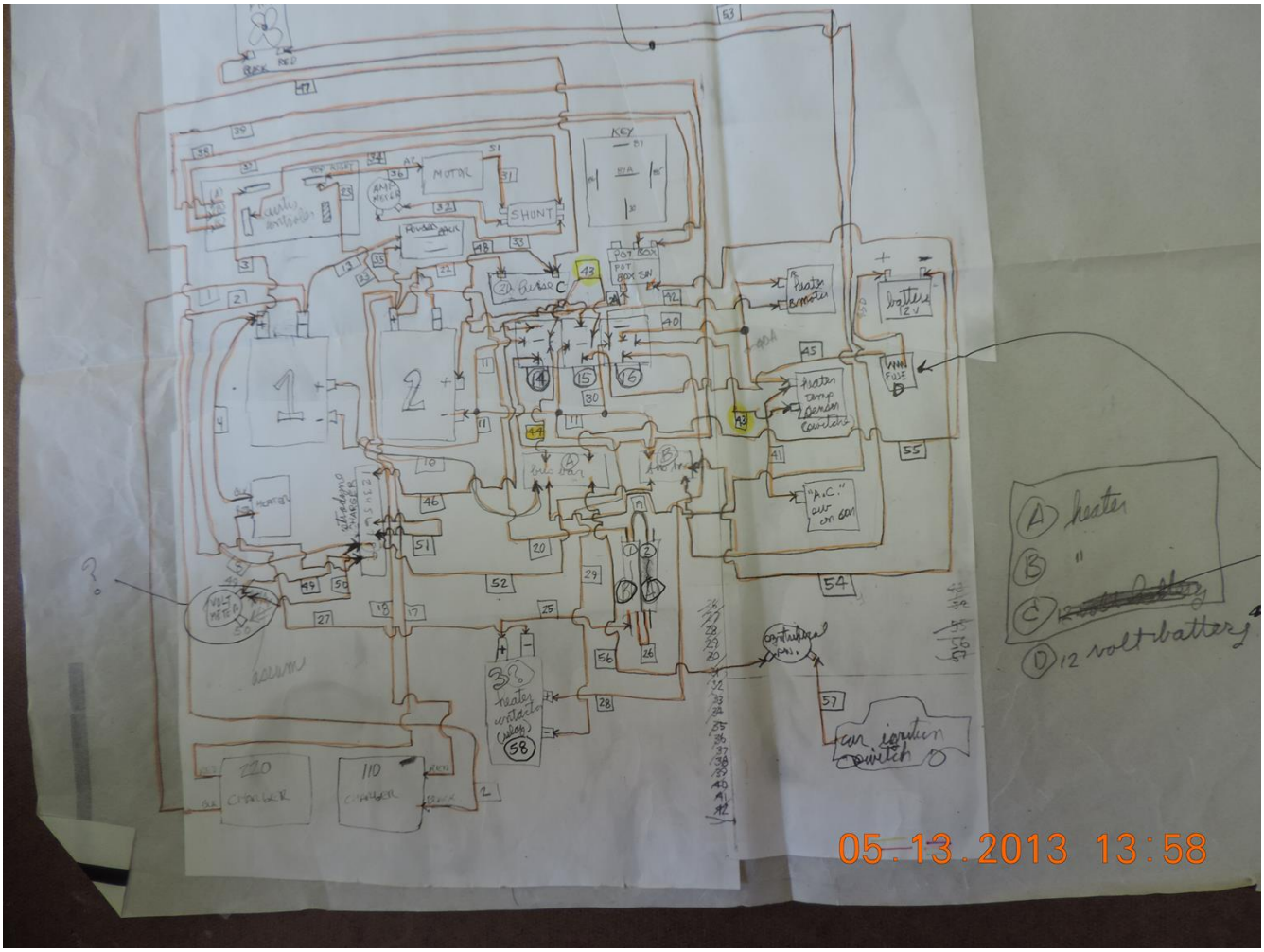


Figure 8 – 1 Our first wiring diagram.

We used colored pencils to trace and retrace the connections. We took no short-cuts. We numbered the wires the best we could. It was complicated --- at least to my eyes. We later discovered that this checking and rechecking effort is on-going. It never stops. We include a few pages here.

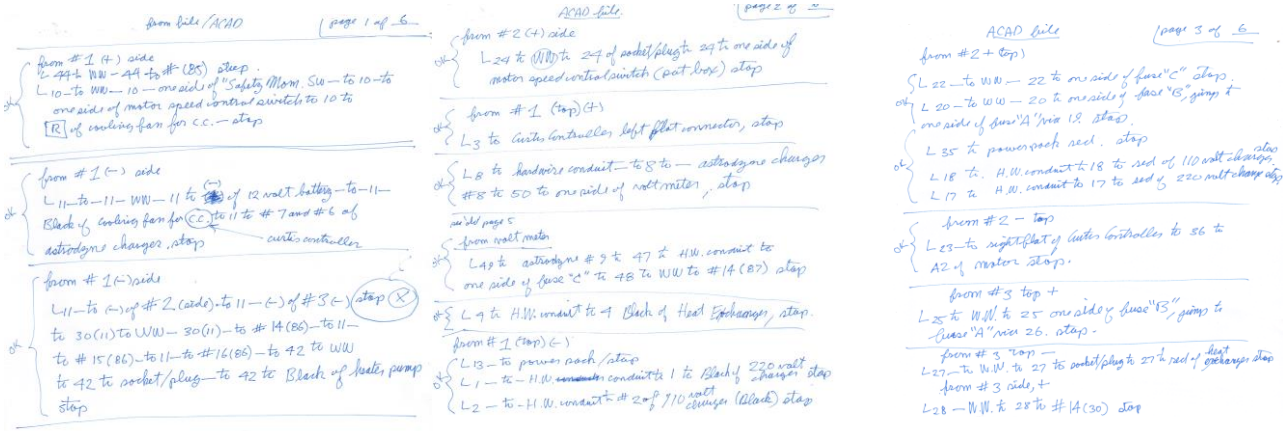


Figure 8 – 2 A small (unreadable) sample of our checking notes.

Faced with this sketchy information, how do you start making a full-blown wiring diagram?

Easy --- on a large blank piece of paper, we put our PENCIL down – remember, most pencils have an ERASER on one end --- never use a pen. Put the pencil down top left. Just like most everything else, "power" flows from top to bottom and left to right. We actually tried to organize our thoughts and put them down on paper. This is what we came up with --- our first thoughts.

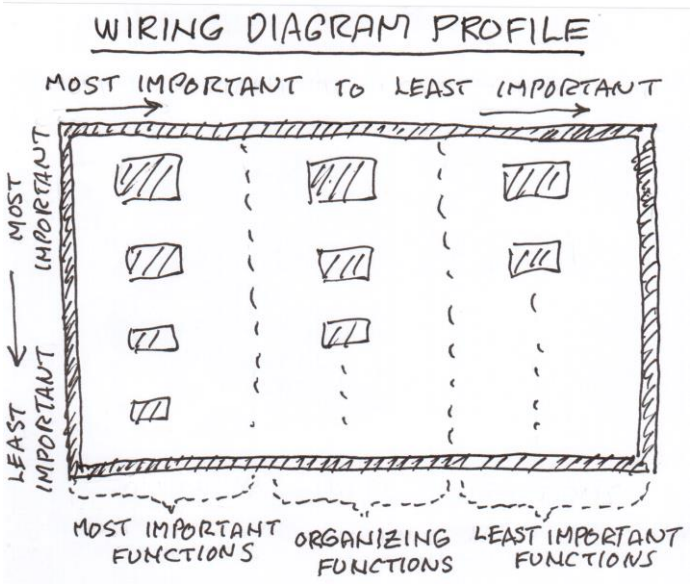


Figure 8 – 3 What we saw in the future.

Thinking of the parts we had, we divided our paper into three vertical sections, shown in Figure 8 – 3 , from left to right..

To the left of the paper (section one), we would place the most significant parts. These would include the Power Pack, the Curtis Controller, the motor, and others.

To the right of the paper (section three), would be the remaining parts. These would be the parts which provide the more common functions such as braking, charging and others.

The center section (section two) would be reserved for the controllers. These would be the parts that operate the "on or off" switches --- providing a flow of sequences that control the various EV functions.

This is our initial concept of the Wiring Diagram. We start with this intent, knowing full well that change is a certainty.

A note to the future. We will ultimately use a combination of these three approaches (#1,#2,#3) to design our Wiring Diagram. All of these will morph into one final solution --- #4 the "Everything" approach. In hindsight, we begin this way ---

<u>#1 --- The "Wiring Diagram Profile" approach.</u>

Following the Diagram Profile (Figure 8 – 3) , we chose the most significant piece of equipment, our big load of batteries --- the "gorilla". We penciled it in, top left, It took the shape of a small box labeled "power pack". That was easy.

What's next --- no problem --- it was the Curtis Controller. Remember, the Curtis Controller controls the batteries. What could be more logical? It also became a box. The next thing that comes to mind, is the Astrodyne Charger. That's the aluminum shiny box that provides power for the 12-volt system. That's easy. It, too, became a box on our paper. The other parts are not so easy nor obvious --- but they're also important --- so we use another means of deciding when and where to arrange these items on our paper.

#2 --- The "Motor Bay" approach.

We slowly moved to considering how we installed the electrical parts in the motor bay. To the best of our efforts, we were trying to follow the "Keys". Keep it simple and easy to understand. We carried on in this way until we realized that there was, yet, another logic to consider --- the wiring. We had to, ultimately, yield to the wiring. This was OK. The first part of our layout was also OK. We just had to merge all of our thoughts together.

#3 --- The "Follow the Wiring" approach .

Big cables rule. In our case, they come in top left. Contrary to our first assertion, the cables do not go directly to the Curtis Controller. They go, instead, to the Contactors --- then they go to the Curtis Controller. This brings up another source of complication. We must consider an immense number of small parts, all of which are big in importance. We punt. We start over. But we're OK. All of our pre-considered notions are still OK --- it's just that we must consider more things --- everything.

#4 The "Everything" approach.

You name it, we got it, we consider it. So we unload all the small parts, so to speak, in the middle of the big piece of paper. We pencil in boxes or symbols which represent the three Contactors, the four fuses, the three small relays and the "scary shunt".

We forgot the motor. We back up. After putting all of the small electrics on the paper, top center, we see that room is getting short. We have room bottom left. Not where we would wish to put the motor, but that's what we're looking at. So be it, the motor is penciled in, bottom left. This time we won't use a simple box but, instead, we drew a reasonable facsimile of the motor. This way we can do our wiring connections, on paper, in a more understandable way --- we look to the "Keys".

Another consideration, we should keep the Curtis Controller close to the motor. Reluctantly, we flip the Curtis Controller and the Astrodyne Charger. We find another necessary item, the Motor Speed Controller. The speed controller is just a "pot" (potentiometer) that controls the speed of the motor and it's attached to the old Isuzu accelerator pedal via an existing accelerator control cable. We're getting close to filling up the paper --- but we have more.

We throw in a few dials for the RPM Gauge, the Voltmeter, the Amp Meter, and the Motor Temperature Indicator Light. Want more? We can't forget the day to day accessories, which includes, among others, the normal car appurtenances --- like the Starter Switch, the Safety Momentum Switch, the Heater Switch, the 12 Volt Battery, the Heater Pump, the Heat Sensor, the Heat Exchanger, the 110 Volt Charger, the 220 Volt Charger, the Power Brake Vacuum Pump, and the Vacuum Switch. Get the picture --- we're not out of the woods yet.

All of these things are penciled in as little boxes. Each box will have terminals and each terminal needs wiring to other boxes which have terminals. So on it goes. You might appreciate the amount of effort it took to create the Wiring Diagram --- so that's why we **capitalize its name.**

********** We need a very critical TIME OUT.

Besides being tired --- we pause to clean house.

We can't go any further. We're at a standstill. In order to make sense out of our overall picture of controls --- we must make sense out of a chaos of wiring. In order to finish our "wiring act" on paper, we must clean up our "wiring act" in the car.

In our hurry to get the car on the road, we fed the connecting wires every which way but the correct way. It was truly chaos in a small spot. We left the wires too long and, in addition, the wires were not adequately threaded through the maze of electrical parts in any meaningful way. We were violating our "Keys". Everything was bad. Nothing was simple nor easy to understand. It was out of control --- we were the creator of " birds' nests". They must go. When this is done, then we'll have a better idea on how to proceed with the Wiring Diagram. We pause for a few examples.

Example 1. Chaos in a small spot.

Figure 8 – 4 Contactor overload.

Example 2.

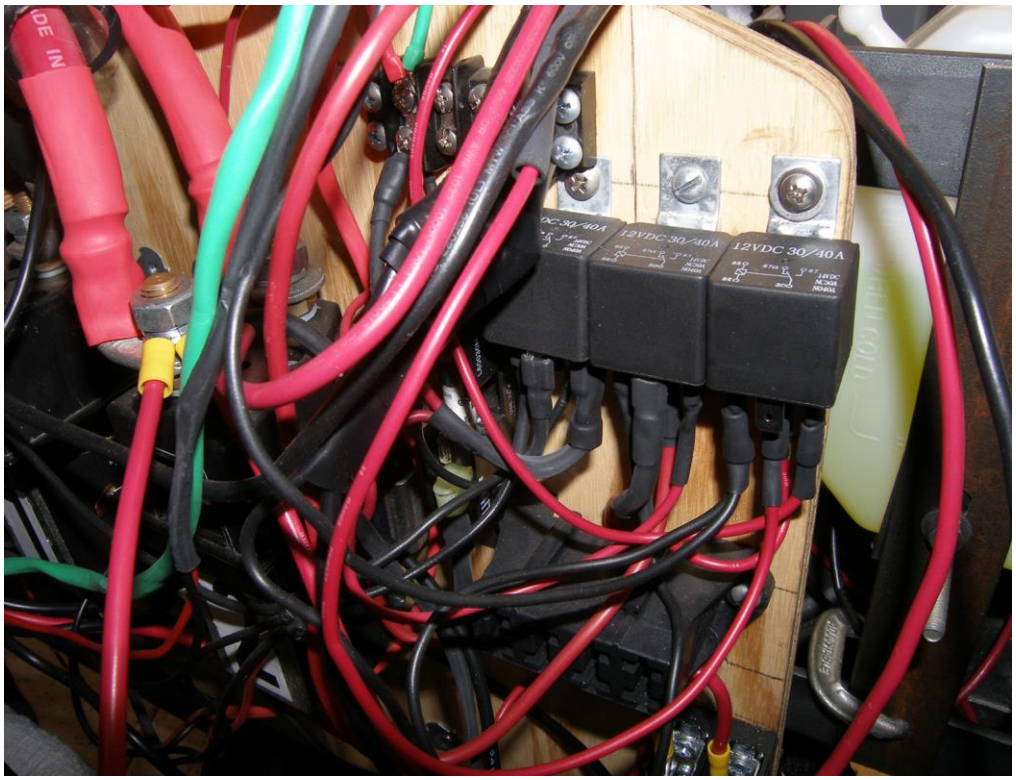


Figure 8 – 5 Relay jam.

Example 3.

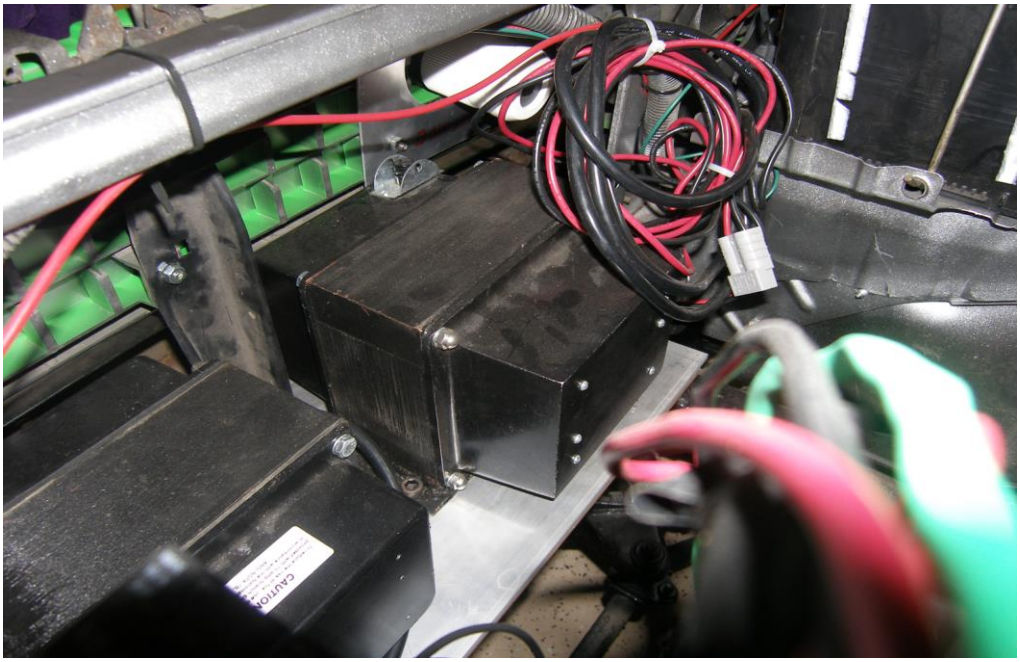


Figure 8 – 6 Charger surplus.

<u>We need help.</u>

Considering the above three examples, we need to pause the wiring diagram process until the wiring chaos is resolved.

We start with the worst. Most of the wiring nightmare revolves around the Contactors, and, to a lesser degree, the smaller gauge wire associated with the three small relays, the four fuses, and the "scary shunt". These are the parts that we had previously grouped together on the vertical table.

Remember. The large 2/0 cables will enter the picture from the left of the vertical table and make head on connections with the Contactors. This was OK. Also, we managed to shorten up the inter connections between the smaller relays --- getting rid of several extra feet of wire. The same is true of the grouped together fuse connections and others. The vertical table was beginning to look neat and tidy. We tried to keep in touch with our "Keys" by compartmentalizing function.

We thought that this concept was working out well. The vertical table was a success. Except for one glaring problem --- the "scary shunt". The "scary shunt" was exposed to curious fingers. No to this. This was our original thought process which lead to the making of the "the house". We needed something to cover the "scary shunt". Easy as that.

We stop to build "the house".

As we would find out later, this idea became the ultimate in organization.

This was a good idea all around. The connections going to the Contactors should be protected from curious fingers and the weather. Since the vertical table was in front and above the motor and within arm's length of curious people, we decided to build a "house" to cover the entire vertical table. Easy.

As we frequently did, we made a trip to our usual home improvement store. We found a box. It was opaque plastic (PVC). It was an electric component box about 12" square and 6" deep. It had a lid and a gasket and it was water proof. Exactly what we needed. We bagged our find and ran home. We attached our new find to the vertical table.

It stuck out too much. It blocked the view of the motor. As we said before, this was a non-starter. We figured that all we really needed was a box 4" deep. We cut 2" from the top of the box. It was now 4" deep and the lid and gasket still fit. Perfect. This box was now becoming our "house". So, just like my granddaughter's doll house, we laid out the "furniture".

A trivia note.

In Traffic Engineering circles, the traffic control devices that you see at busy road intersections --- such as traffic control lights, the "no U-turn" signs and others --- are referred to as traffic "furniture".

We smile and move on.

The old man and his “house”.

Figure 8 – 7 We position the “furniture”

We grouped like parts together (fusses and small relays). The Contactors were still to be reckoned with, but we grouped them also. Everything was perfect but the wiring crept up on us again.

As always --- The 0/2cables rule.

We move on.

More “furniture”

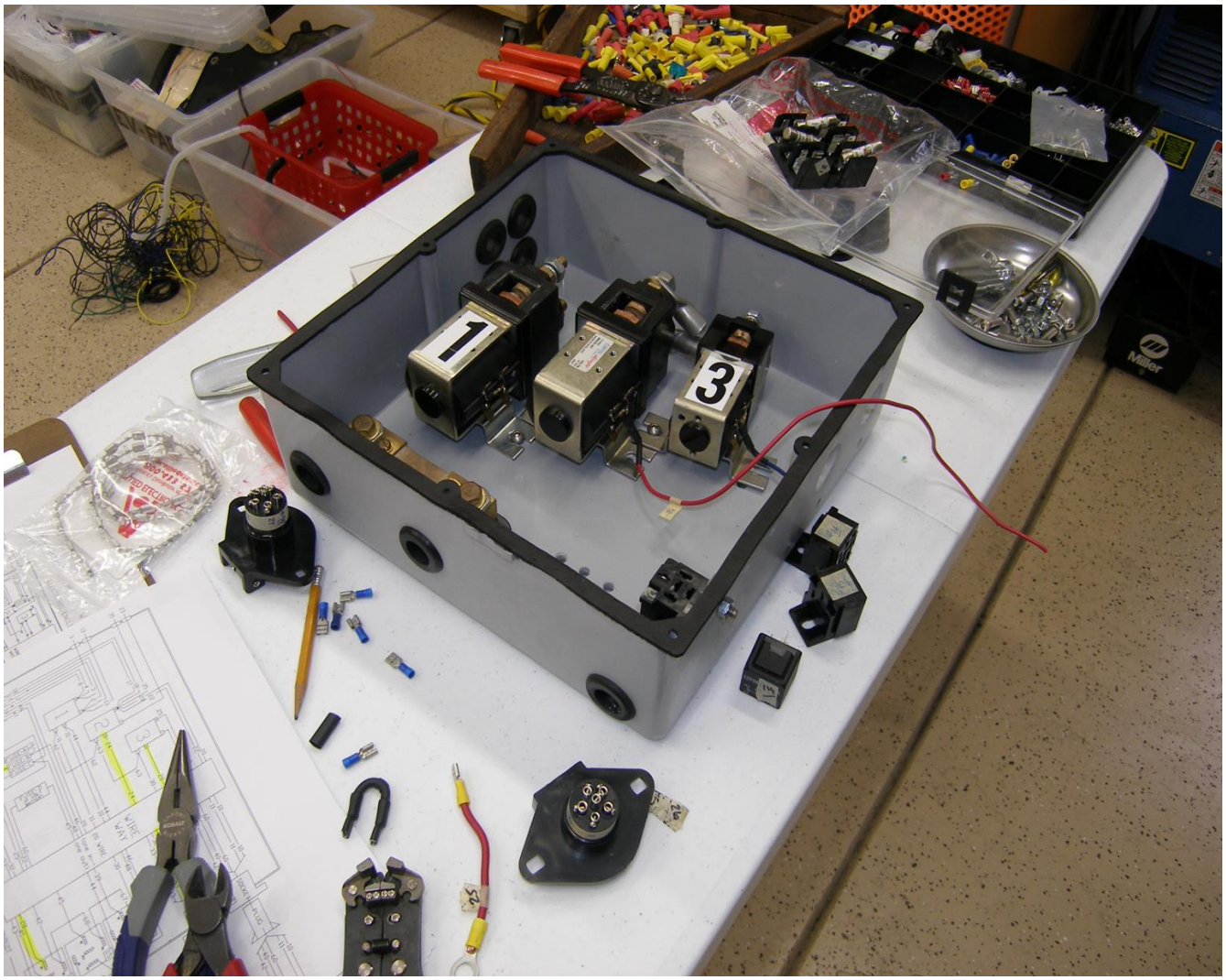


Figure 8 – 8 We had no choice but to stagger the Contactors.

We knew that we were going to have trouble with the 2/0 cables. And we did. The 2/0 cables would have to enter the box from the top left side and go straight to the Contactors. This automatically fixed the Contactor's location.

We located the small relays on the wall of the box, upper right.

The fuses will take up the central position with the large fuse on the wall, lower right.

The scary shunt goes lower left.

We tried to keep our “Keys” operating.

Figure 8 – 9 We wanted a configuration that made sense.

The location to the Contactors were stone cold permanent. They were staggered and ready for the 2/0 cables.

Note the dowels. We used dowels or broom handles cut to length and the ends carved to receive the actual cable ends to simulate the cables bolted to their respective Contactors.. In this way we could locate, as closely as possible, the exact entry or exit location of the cables as they would pass through the box wall. We aimed for a perfect alignment of the cables --- no stress.

The “scary shunt” location is set at this point. We used the actual cable ends, bolted to the shunt, to locate cable entry locations. The shunt was as close to the bottom wall as we could make it.

Fuse locations were not certain. We wanted them grouped together, but, at this time, three were on the floor of the box while the fourth was to be positioned on the wall (Note finger holding the fuse on the wall).

Note also that the small relays, numbers 14, 15, and 16 were located at upper right.

Some of this will change.

Locating the 2/0 cables

Figure 8 – 10 Cables rule. Note the rubber grommets fixed in the holes.

The 2/0 cables entered the box twice and exited the box twice. This number of wall penetrations was a problem. Something we could not avoid. We wanted to maintain as much weather proofing as possible. Wiring, of all types and sizes, entering and exiting the box was not good. After a long search, we finally found grommets for the large 2/0 cables. These rubber grommets fit the box wall (1/4” thick) and fit the cables snugly, exactly what we wanted. We're good --- except for the smaller wire..

The Ultimate Fix --- almost.

We were swamped with smaller gauge wire. But, we had a great idea --- this was fun. We went for “plug-ins”. The same plugs used for trailer brake lighting. The units we chose could pass 6 wires per plug. We chose to use two plug units. This would allow 12 total wires to pass through the wall of the box --- all waterproof --- this was great, almost. The plug electrics could only handle smallish wire. We were comfortable with this, but we had need for some larger wire that the plugs couldn't handle. Larger plug units proved to be too big and too expensive (we looked all over the map).

The ultimate fix.

Figure 8 – 11 The ultimate fix. This was more pleasing than cake and ice cream.

Keeping track of the numbers.

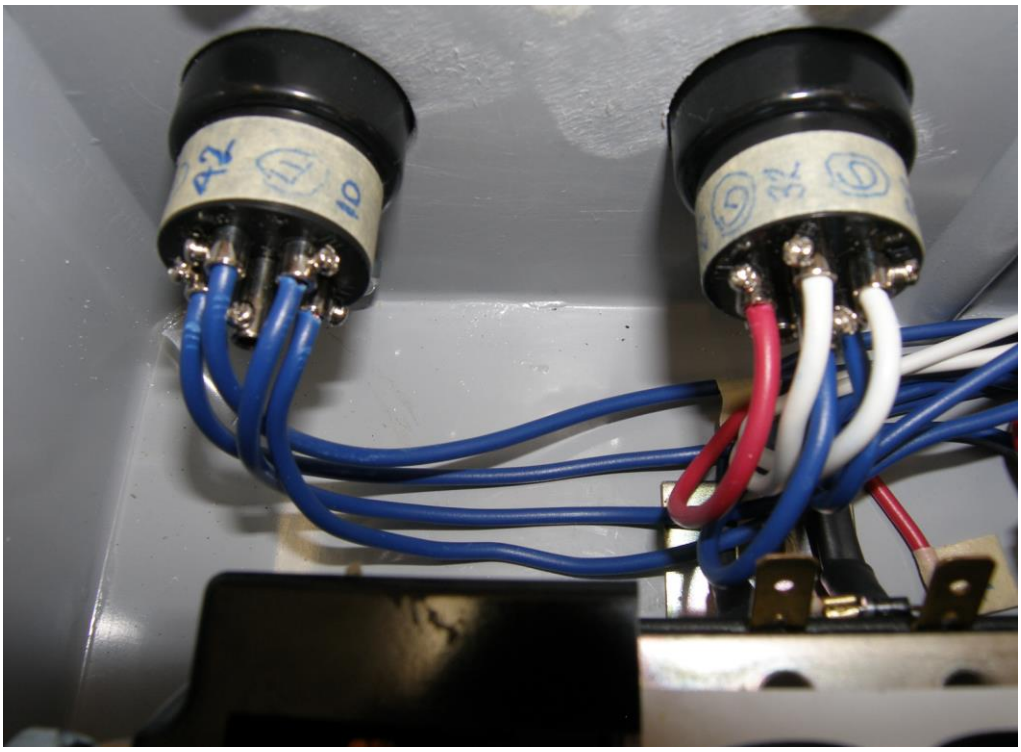


Figure 8 – 12 An account's job --- tracking the wire.

Close to the final layout.

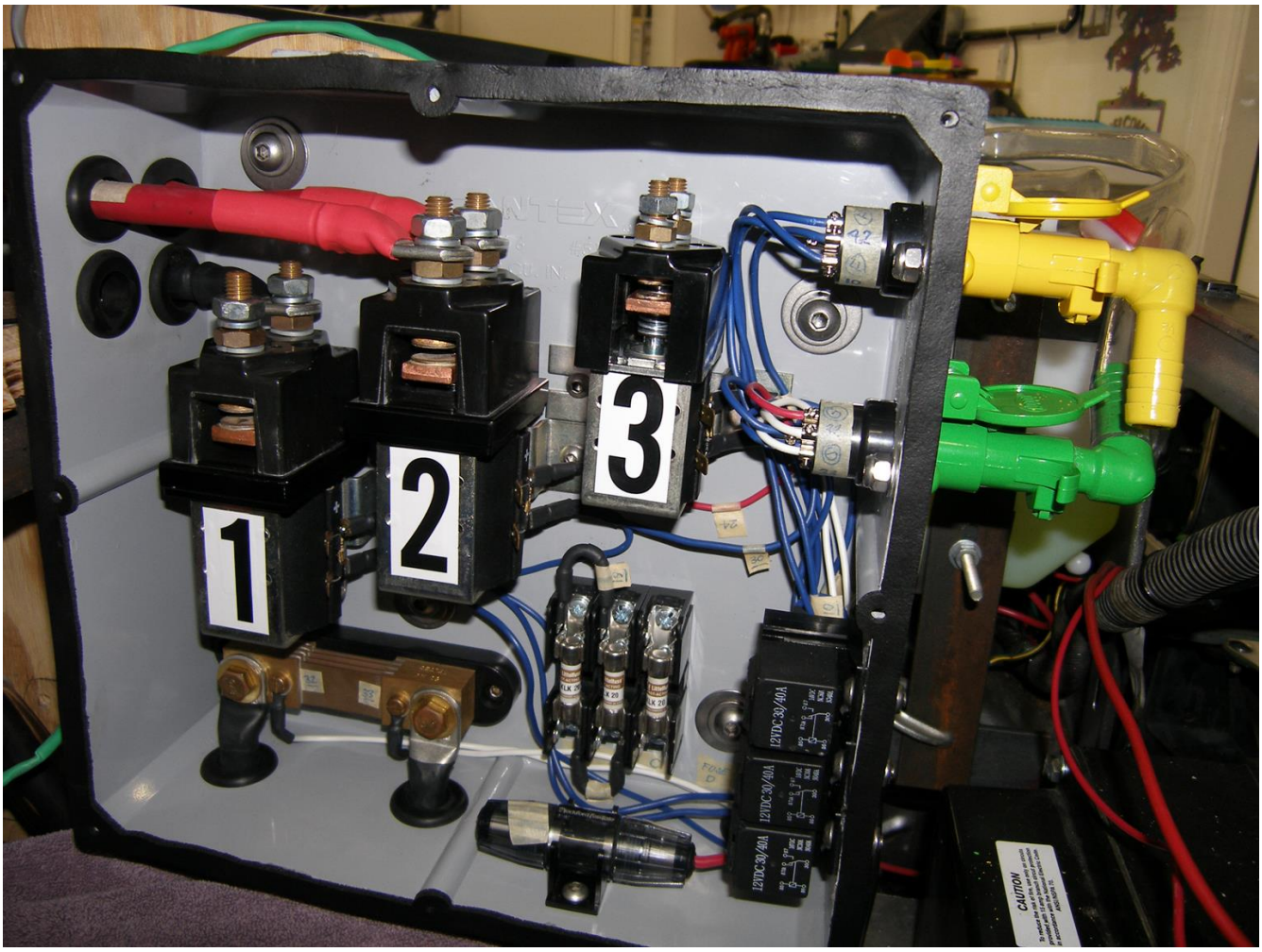


Figure 8 – 13 Close to our final configuration.

We had another ten wires to accounted for. These were the ones the sockets couldn't handle. We chose to bundle the ten wires separately. We would pass the additional ten wires through box wall, but, this time, through the bottom of the box with a snug fit grommet.

We're close to finalizing our “house” , but we can’t close the final door without the “scary shunt”. We wanted to avoid the “scary shunt” as much as possible so we put it lower left, in the corner. This proved convenient because it needed just two heavy inputs of 2/0 cable through the wall. These ran directly through the bottom wall via grommets. The “scary shunt” was now safe and out of the way. Our “house” was getting full. Wiring has taken its toll. We freed up floor space by moving the three small relays. We changed them from a floor mount to a side mount. We put them on the wall of the “house”. The four fuses were next. We wanted them to be displayed visibly, on the floor, all in one spot. Until proven not, our “house” was built. We loved it. We changed out the opaque lid for a plastic translucent amber. It was beautiful. You could see all of our electrical parts --- are we crazy or what ? (You need not answer) We move on.

********** We return to the Wiring Diagram.

Our first attempt --- which includes the “ House ”.

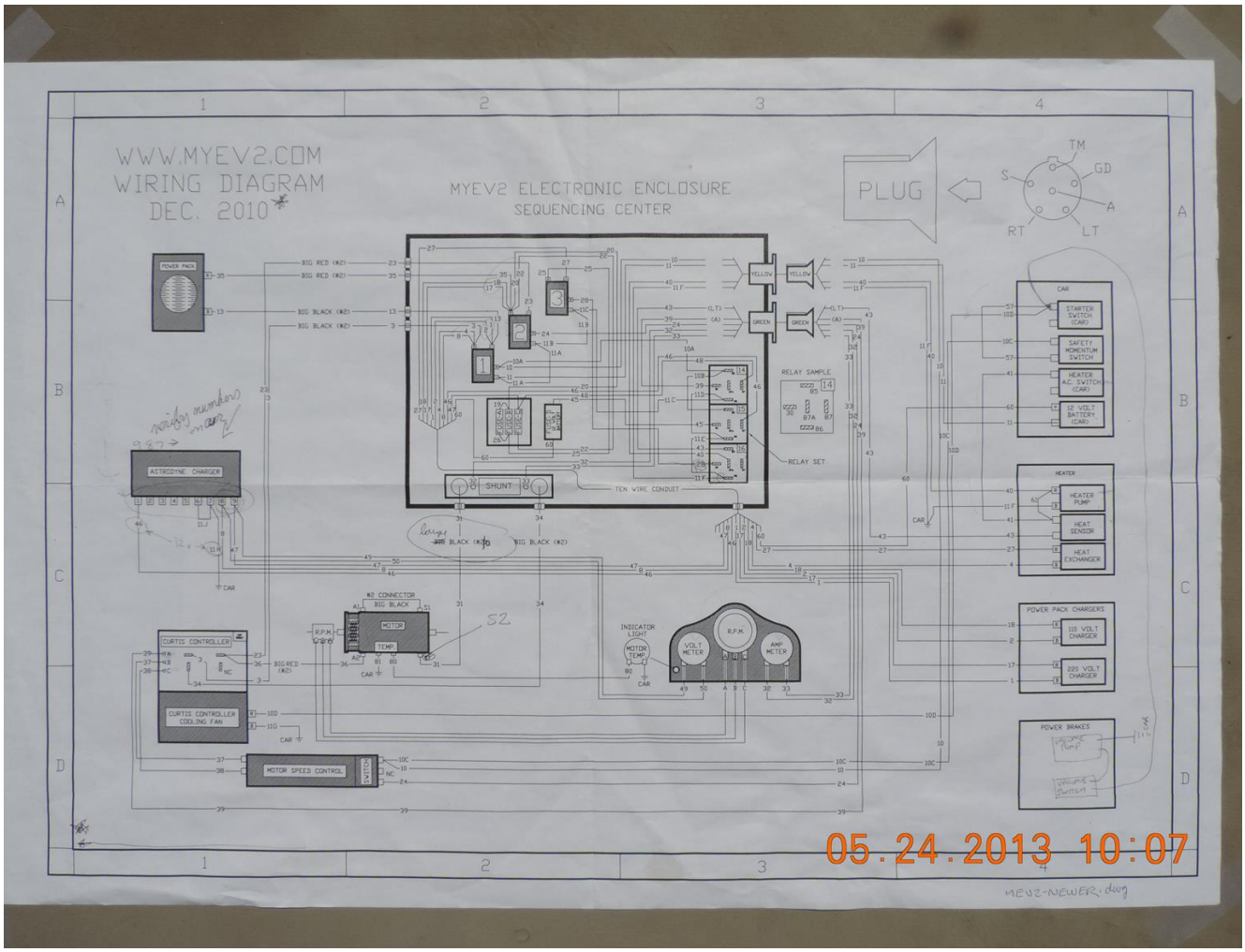


Figure 8 – 14 A “portrait” view of our Preliminary Wiring Diagram with indicated corrections (pencil).

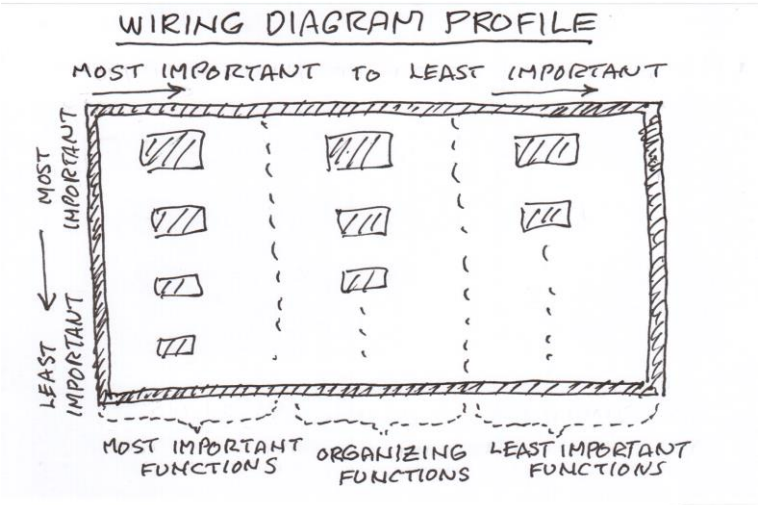
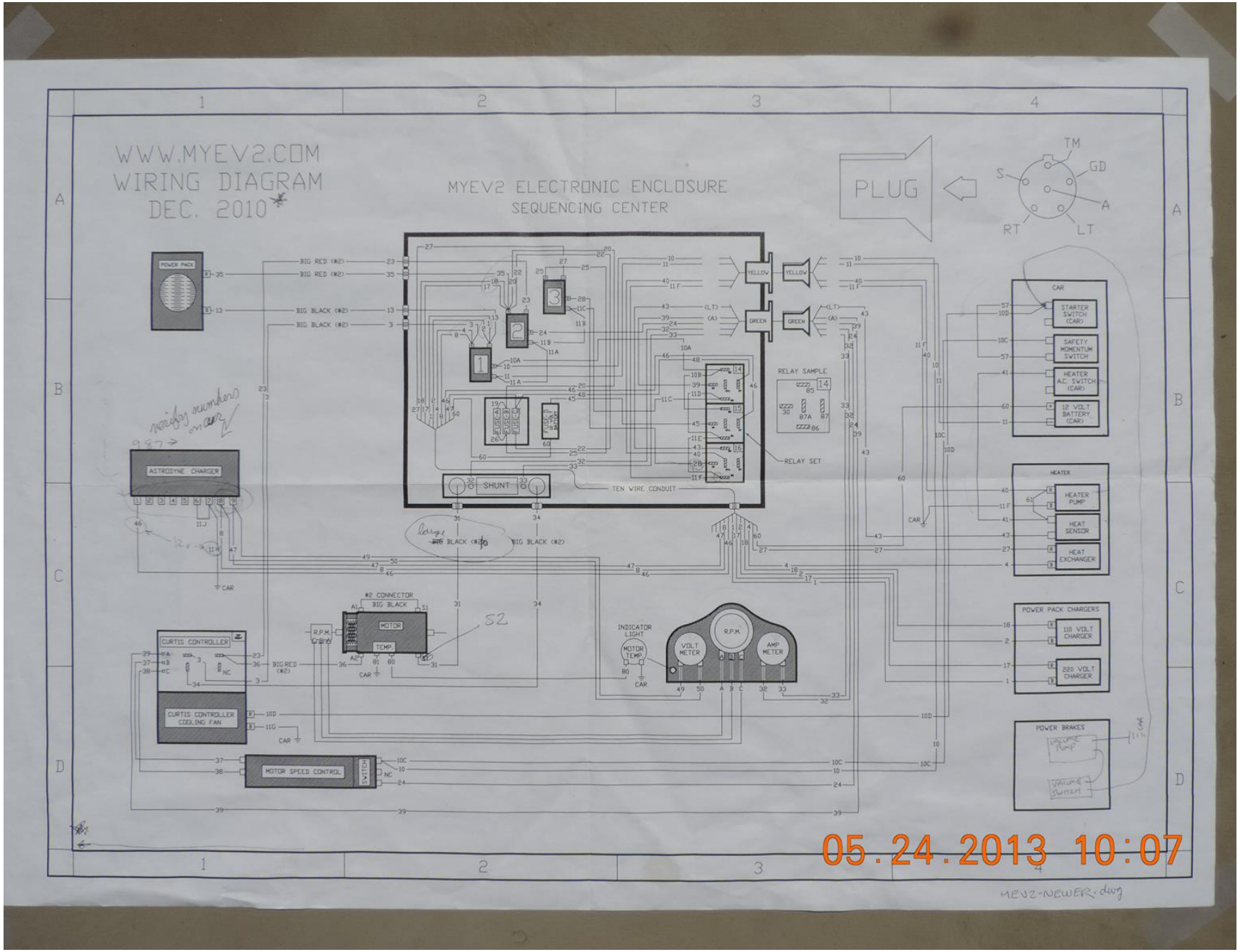


Figure 8 - 15 Our first thoughts --- see the resemblance?


WWW.MYEV2.COM
WIRING DIAGRAM
DEC. 2010
MYEV2 ELECTRONIC ENCLOSURE
SEQUENCING CENTER
PLUG
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POWER PACK
ASTRODYNE CHARGER
SHUNT
TEN WIRE CONDUIT
RELAY SET
RELAY SAMPLE
CAR
STARTER SWITCH (CAR)
SAFETY MOMENTUM SWITCH
HEATER A.C. SWITCH (CAR)
12 VOLT BATTERY (CAR)
HEATER
HEATER PUMP
HEAT SENSOR
HEAT EXCHANGER
POWER PACK CHARGERS
110 VOLT CHARGER
220 VOLT CHARGER
POWER BRAKES
VACUUM PUMP
VACUUM SWITCH
#2 CONNECTOR
BIG BLACK
MOTOR
TEMP.
R.P.M.
CURTIS CONTROLLER
CURTIS CONTROLLER COOLING FAN
MOTOR SPEED CONTROL
SWITCH
INDICATOR LIGHT
MOTOR TEMP.
VOLT METER
AMP METER
BIG RED (#2)
BIG BLACK (#2)
YELLOW
GREEN
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Figure 8 - 16 The preceding page is a “land scape” view. The largest we can provide.

Detail of the “furniture” in the “house”.

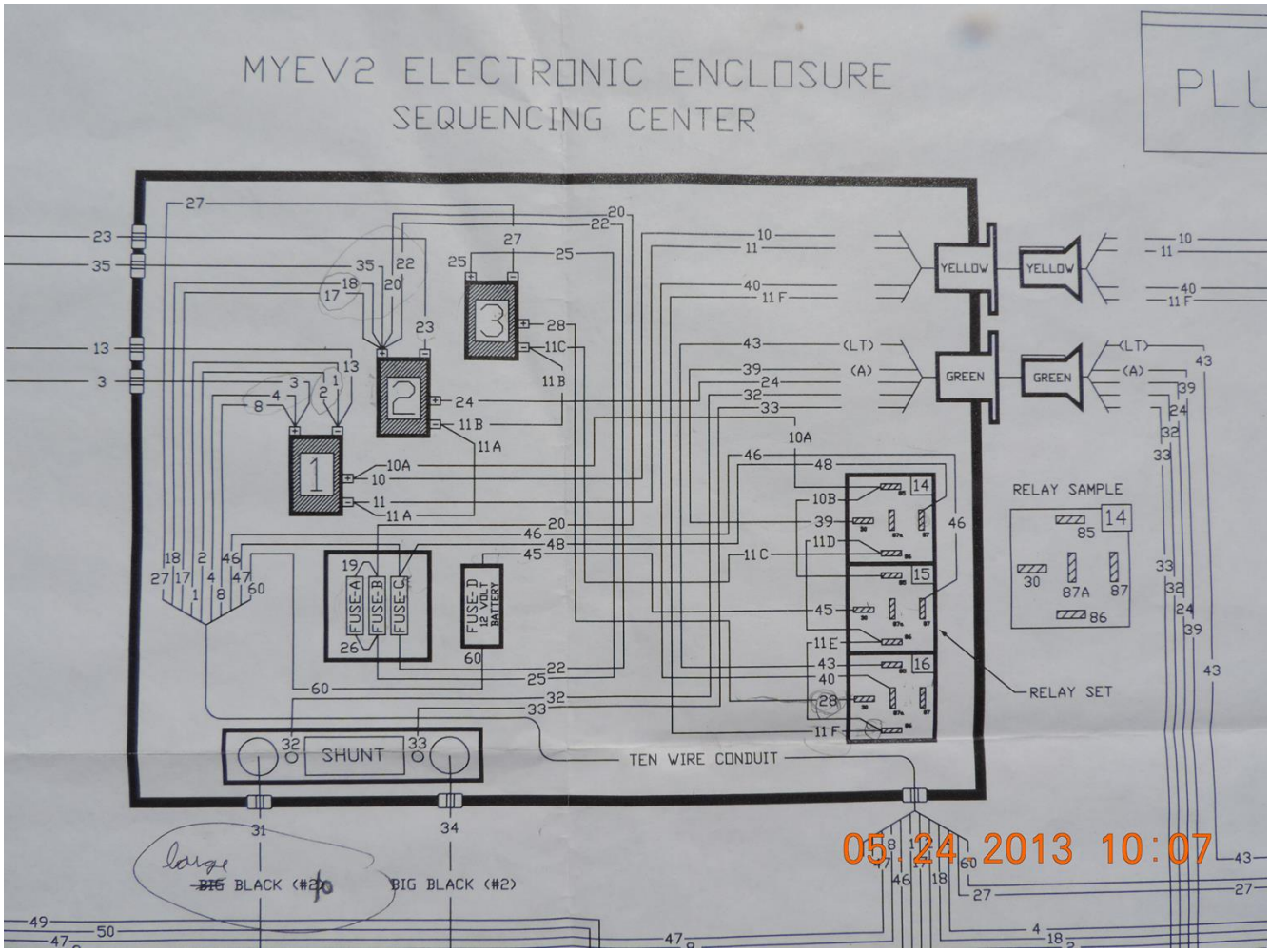

Figure 8 - 17 The Sequencing Center box (the “house”). Corrections indicated in pencil.

There you have --- so much for that --- back to the Wiring Diagram. We were satisfied and happy. We decided to give the “house” its rightful spot on our wiring diagram. This is dead center front. It really deserves this spot because the “house” contains the items that control the motor plus much of everything else. It's important. In this regard, we dropped our beloved “house” nomenclature and renamed it a much more formal name, the Sequencing Center --- as it sequences the EV's electrical functions --- but, for us, it will always be --- the “house”.

We can't say more. This is the final answer.

<u>Using the latest magic.</u>

Yes we did --- we used the latest magic while you weren't looking. We were lucky enough to use a computer aided drafting machine (software on your laptop). That's why the Wiring Diagram looks so neat. Otherwise we would be back to square one with our original coffee stained scrap paper.
The real benefit of using computer aided software is that changes can be made --- <u>whole-sale.</u> As you might imagine, this is really beneficial.

Get one. You don't need all the bells and whistles, just straight lines. Even cross-hatching can be done using only straight lines. If you haven't used one, this new experience will raise your innovative abilities. Compare it to the difference between a mechanical typewriter and a computer word processor. Your local college may be a source for you, or you might check on lower priced software and directions. No need for bells and whistles. Get one.

PART NINE --- MISCELLANEOUS PARTS

Our plan here is to describe all the rest of the parts associated with the Wiring Diagram. But first, we will depart and play with a little bit of Play-Doh instead.

We Play-Doh the "house". Yes, we want to actually pick up the "house", by our hands, and relocate the physical location of the "house" as it sits in the bay. Really! We want it front and center --- because it's our super quarterback. It will stay on the vertical board --- we just want to optimize its position. We want it as high as possible and out front as far as possible --- and do this without contacting the Isuzu hood when you slam it closed. Easy.

We carefully detached the entire box from its wooden vertical table (it was still wired) and moved it forward and up and temporarily reattached it. We then carefully lowered the Isuzu's hood. We obviously couldn't see anything, even though the hood was not all the way closed. We didn't want to damage the hood, nor the box. There was no space to crawl inside or beneath the hood to check the clearance between hood and box.

We just wanted it perfect – maybe a ¼ inch from disaster (the Isuzu hood). Mike solved the problem.

<u>We "Play-Doh" the box.</u>

Mike snuck (this was early in the morning) a piece of Play-Doh out of his daughter's toy box. We put a glob of Play-Doh on the top right corner of the box and , again, carefully pressed the hood down. Our aim was to place the box so that there was about ¼ " of free space between the closed hood and the top right corner of the box.

We repeated this operation until we were satisfied with a good and safe clearance. Play-Doh is good. Check out the top right corner of the Sequencing Center box, Figure 9 - 10. Notice that the top right corner of the box sticks out above and beyond the vertical table. Nuf said --- Play-Doh is good.

<u>Other parts and functions on the Wiring Diagram</u>.

We now move from the center of the Wiring Diagram to the right of the paper. Less exciting, yes, but still important. The items here are the things that we take for granted. It's the starter switch, the safety momentum switch, the Isuzu 12-volt battery, the heater, the chargers for the Power Pack, the Power Brakes, and the Instrumentation. We'll speak about a few of their particulars.

The Starter Switch.

The starter switch is the same switch as the Isuzu gas motor switch. The scary thing is that when you turn it on --- nothing happens, no noise. Touch the brake pedal, and there is a "ticking" sound. That's the power brakes pumping. Touch the "gas" peddle and you move --- if you're in gear. Note, the EV can be started while the car is in gear --- just keep your foot off the accelerator pedal.

The Safety Momentum Switch.

The Safety Momentum Switch turns off the Power Pack in case of a collision. This switch should be located somewhere in the forward part of the car. Probably on the fire wall. The Safety Momentum Switch comes in at $45. Its billed as First Inertia Switch – Auto Shutoff (12V System.)

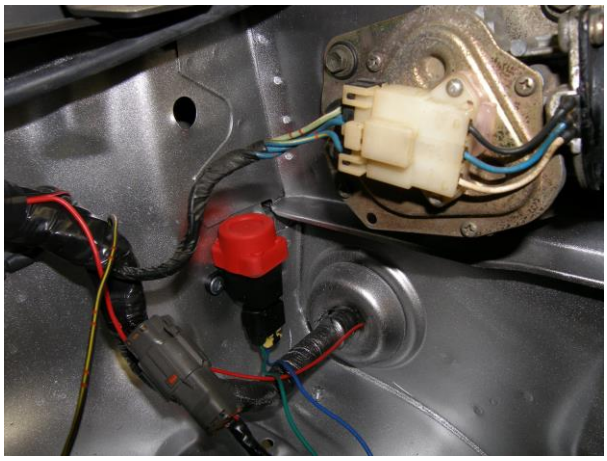

Figure 9 - 1 Safety Switch on the fire wall.

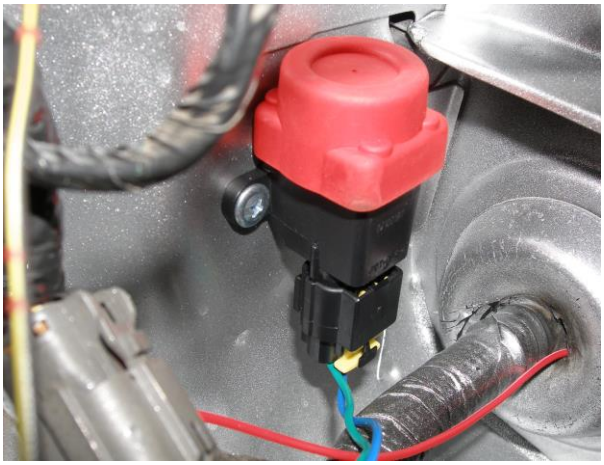

Figure 9 – 2 Safety Switch mount.

The Motor Speed Control.

That's the formal title. The informal title (story) is The "Pot Box" and the "bent paper clip".

The Motor Speed Control is from Curtis Instruments, www.curtisinstruments.com. The model number is PB-6 and comes with a built-in micro-switch. It sells, thru EVA, for $90., 2008 prices. The PB-6 comes in an open format (no enclosure). It's just a potentiometer (" Pot Box" , for short).

Our "Pot Box" has made its rounds of various positions. They range from vertical to horizontal. The only thing that really governs it mounting position was the old Isuzu accelerator cable. As with most mechanical "push-pull" accelerator cables, sharp bends should be avoided.

For our initial go at this , we mounted the "Pot Box" on the back side of the vertical table. This kept it out of "harm's way" and allowed only a large, slow bend. This was the way we used it was on our first drive. It worked OK.

The first position of the “Pot Box” .

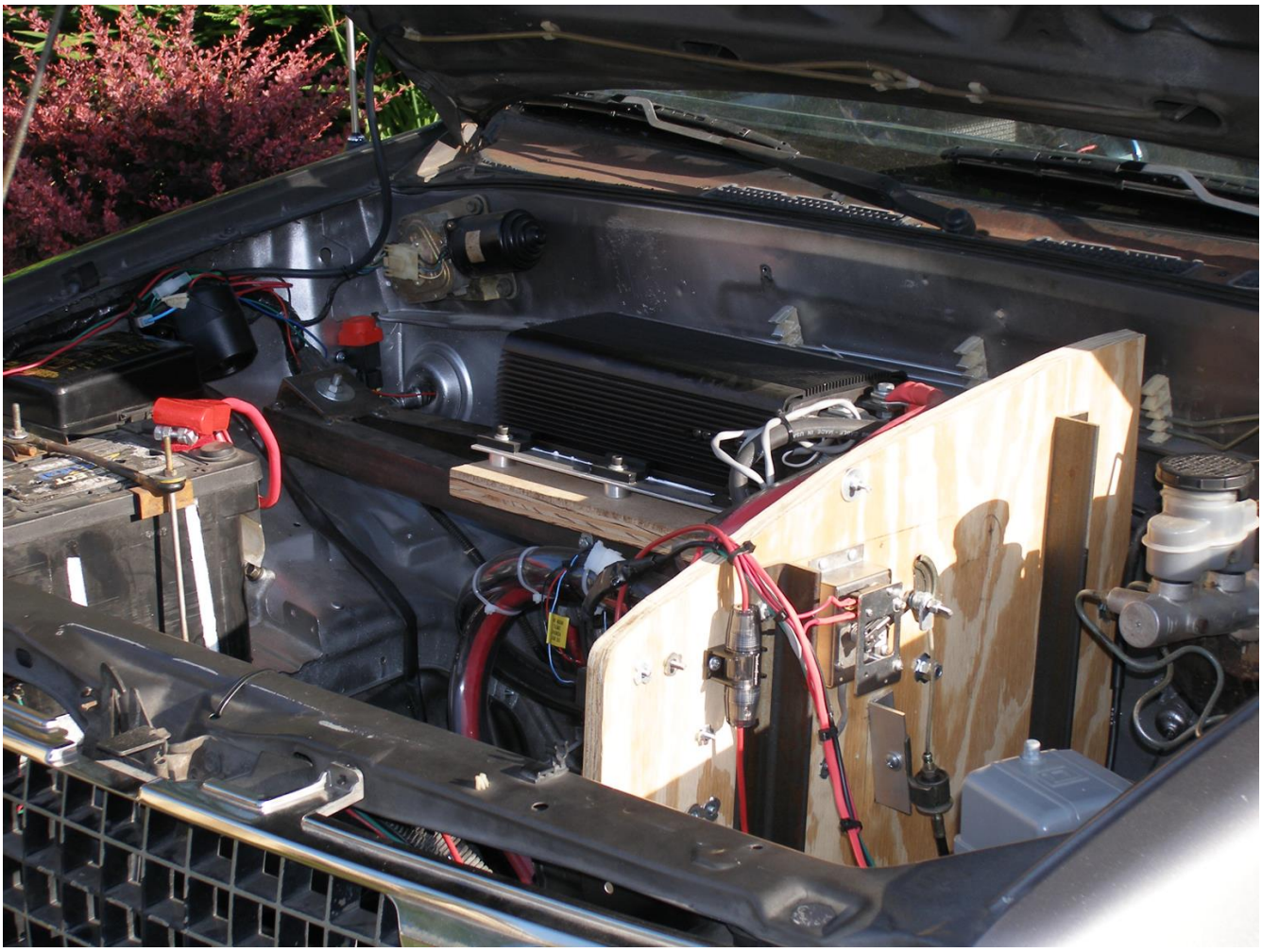

Figure 9 – 3 The first placement of the “Pot Box” . On the backside of the vertical table.

Figure 9 – 3 and 9 – 4 show the connection of the EV “Pot Box” with the Isuzu throttle cable. Notice the strange looking wing, top right of the “Pot Box”. We don't know what function the “wing” has but we left it on. It belonged to the Isuzu. We couldn't take it off, we tried. It was still on when we turned the key for the first time. At that time, there was no convenient way to connect the “Pot Bot” operating arm to the stock Isuzu throttle cable, we finally wired them together with a piece of wire. We found that a paper clip was pliable enough to do the job. It worked.

We knew that the “Pot Box” had to be redesigned in the near future as it needed an additional spring. The “Pot Box” comes with an internal return spring from the factory but it was strongly suggested by EVA that we redesign the operation of the unit to include a redundant spring.

After our first drive, we reconsidered the placement of the “ Pot Box”. The vertical table was not the best place. It needed a straight on connection to the Isuzu throttle cable.

The original “Pot Box”.

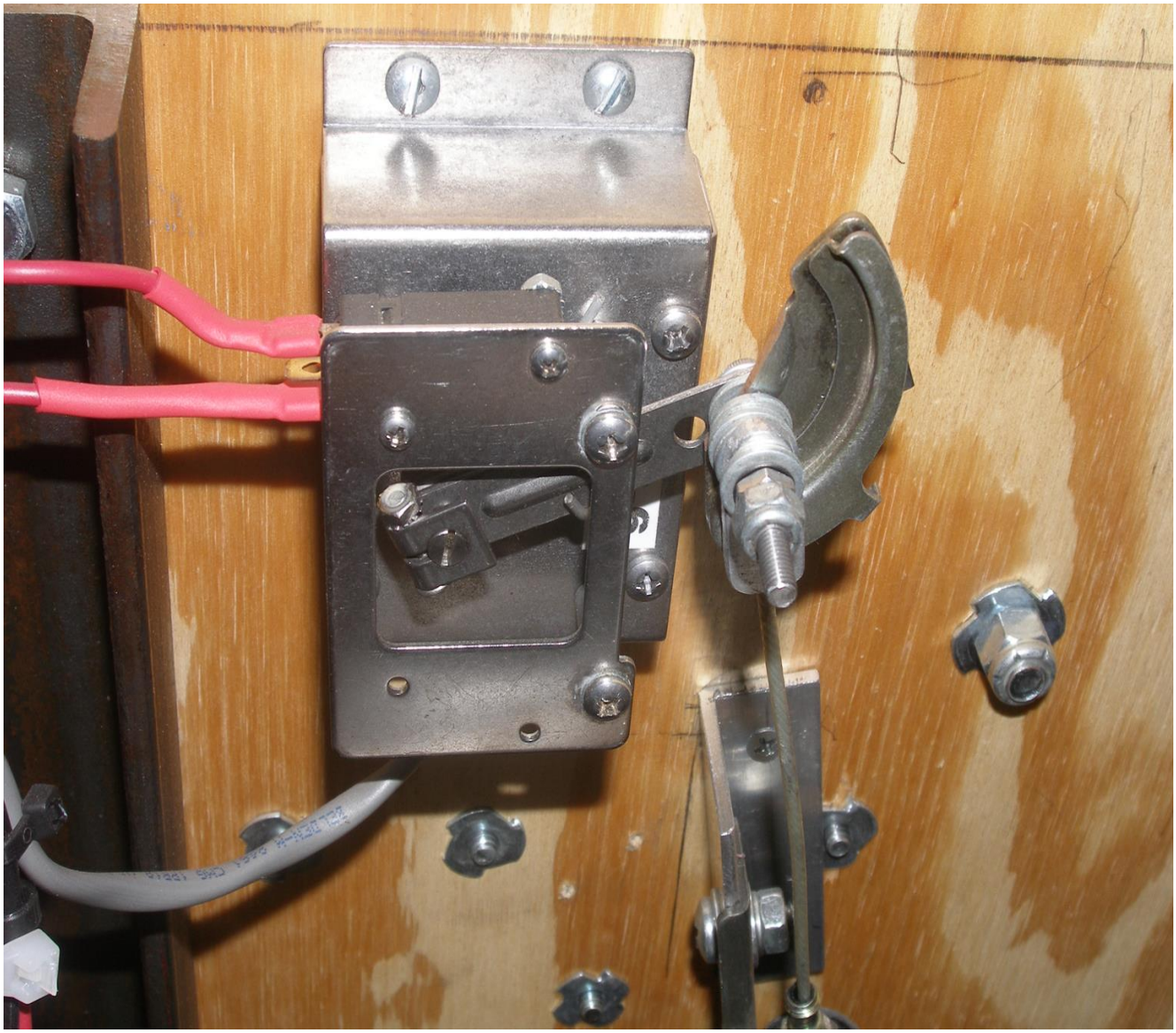

Figure 9 – 4 Detail of the “Pot Box” located on the vertical table.

The best spot, we concluded, was a position that allowed the throttle cable to be in the same position as the original Isuzu cable. So we aimed for the top of the inner fender well. In addition, there were existing holes on the fender well that we could use. We had further modifications to be included and the fender location looked probable, as we needed more room to lengthen the unit to accept a longer external return spring.

Because of the above considerations, we eventually mounted the “pot box” on a longer piece of wood. As decided earlier, we moved the Speed Controller to the fender well. Everything looked OK but the Isuzu wing and the bent paper clip had to go. To replace this “Jerry-rigged” connection, we wanted something fail safe, something that we could count on, all the time. We hunted sources locally and even sources outside of California.

We made the rounds, as usual, but nothing. That " fail safe" requirement took its toll. We wanted something made for a specific purpose. We tried motorcycle shops, they had what we wanted, but this scenario gets complicated very, very fast.

This is how it went --- Mike went on the internet and found a speed shop --- they sold Summit Racing Equipment. They were located in Sparks, Nevada (that's important). This may not seem important, but some parts are not legal for sale or use in Californian on any pollution-controlled motor vehicle. This is just a lowly mechanical connector but, who knows. So this lowly connector (about as big as a bent paper clip) cost us $ 87.13 (2008) --- but it really works good and makes Mike smile a lot because we finally bought something from an honest to goodness, first rate, speed shop. We actually do have a picture of this pricy connector. We noticed it in a picture of the heater system. It's that piece just above the arm of the ugly "Pot Box". It's about 1 1/2"long and connects the Isuzu throttle cable with the arm.

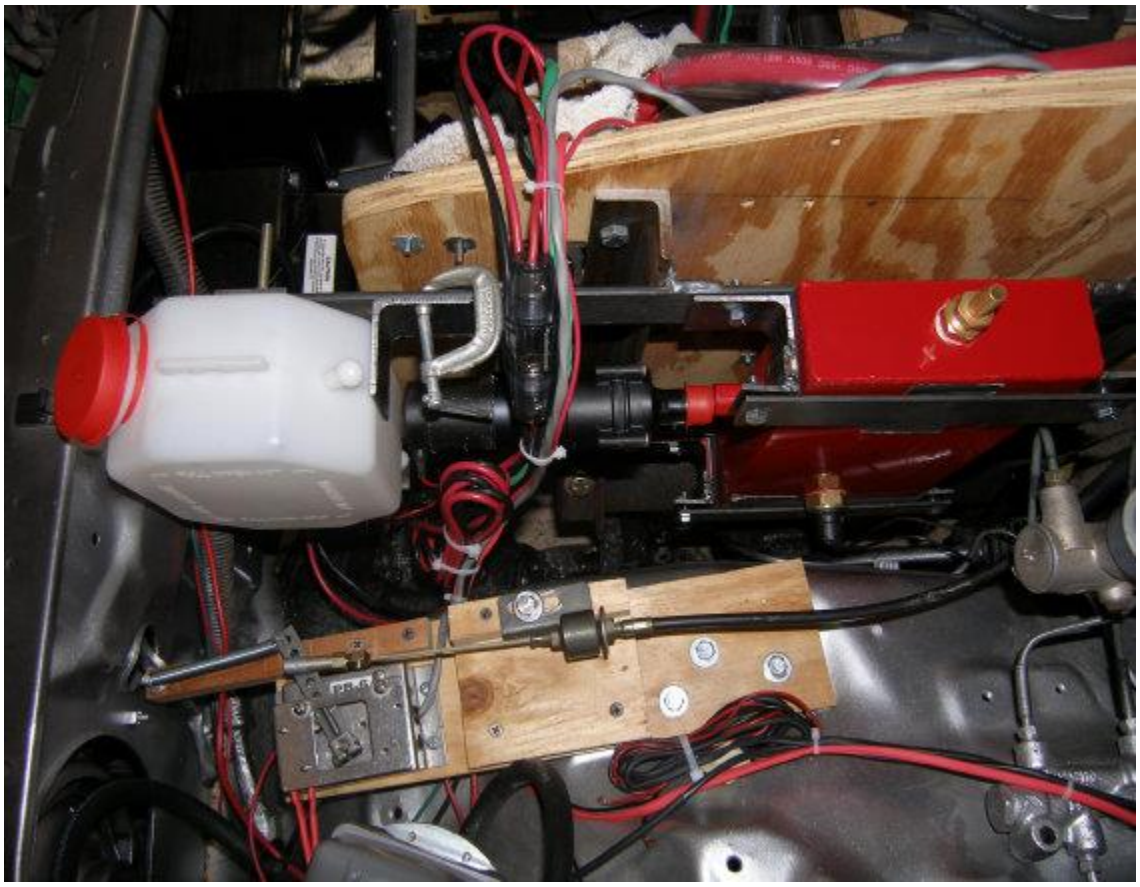

Figure 9 – 5 The ugly "Pot Box" with the $87.13 connector --- find it?

The price for the "pot box" is mounting. My $2.00 calculator says $177.13. Everything was going well --- but, to be honest (which we always are), that wood crap was not looking good on our expensive speed shop equipment. So we went to several home supply stores and surplus metal stores (they know us by our first names). We bought various types of aluminum extrusions and put it all together. We jettisoned the old wooden base for 1/4" thick aluminum plate. We finished it off with an outstanding framed aluminum box with transparent amber plastic top and sides --- so you can see the "speed equipment". Unfortunately, we have no pictures of this final design.

The 12-volt Battery.

The 12-volt battery is located (in our case) in the same place as it was for the Isuzu. It's a separate system, not connected to the EV except for one important thing, the 12-volt battery gets charged through the Astrodyne Charger. Remember, the EV has no generator or alternator. The lights, radio, power brakes and other electrical items run directly off of the Isuzu's 12-volt battery system.

The Heater.

The heater: This system is rather complicated but straight forward. First of all, the heater is required by the State of California for no other reason than to defrost the windshield. Keeping you warm is not a requirement. Important for the EV driver (our car) is that the power to produce heat comes directly from the Power Pack. This will affect your driving range. Other than that, it really works good.

The inline heater.

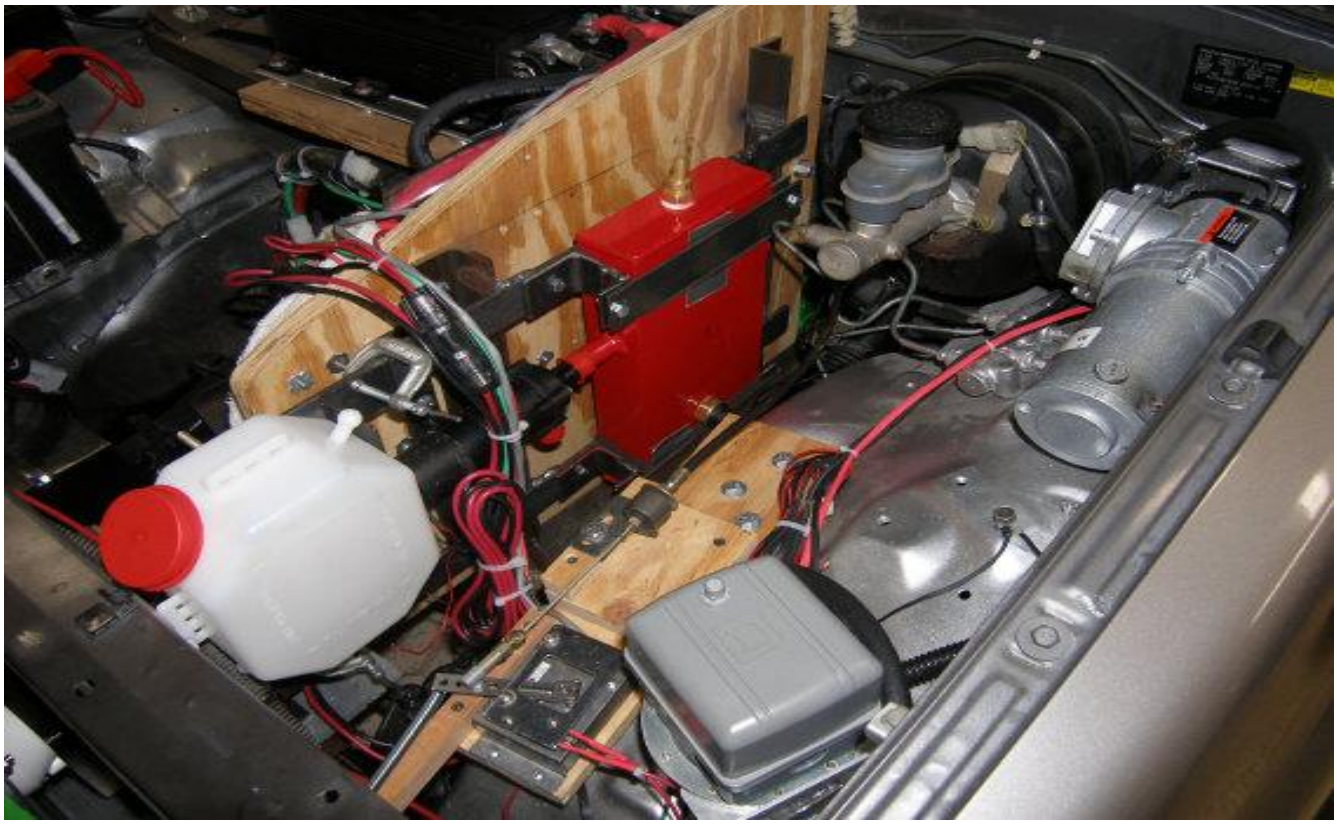

Figure 9 – 6 The Heater, in a row, as per the "Keys"

In keeping with our "Keys" (compartmentalizing function), we installed all of our EV heater parts in a single row, directly behind the vertical table. From left to right, the coolant reservoir, an inline electric pump, and a heat exchanger.

Heat exchanger.

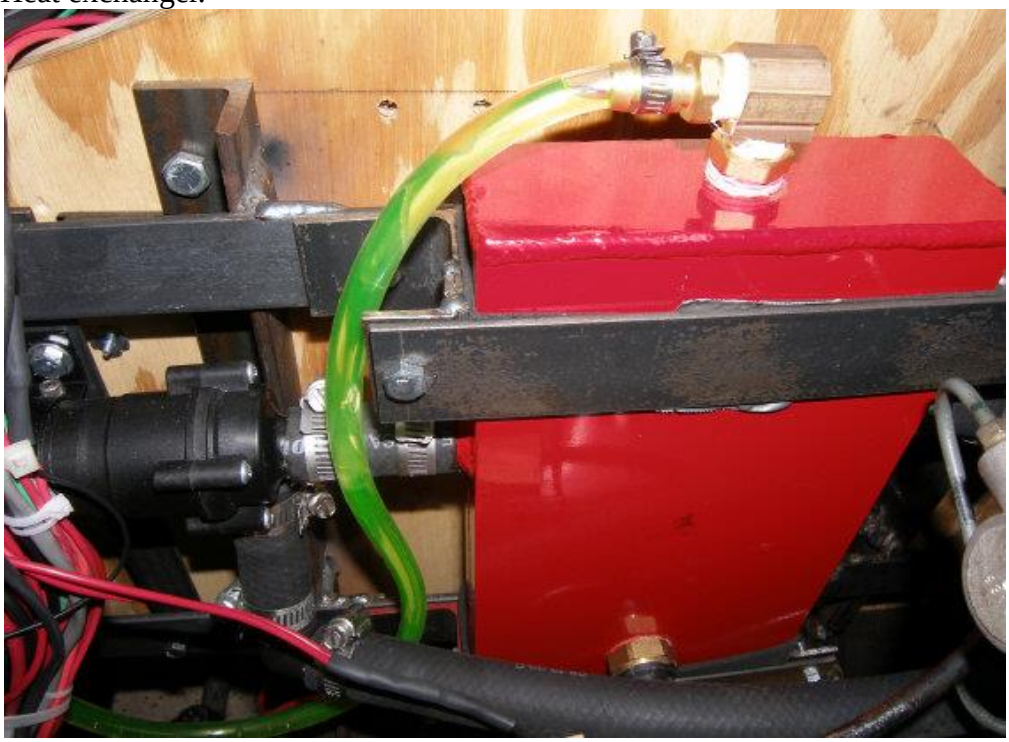

Figure 9 - 7 Detail of the pump to heat exchanger connections.

The system works like this: The pump draws the coolant fluid from the container and feeds the fluid, under pressure, to a heat exchanger, where the Power Pack energy heats the fluid under the control of the Sequencing Center and a local temperature sensor. The pump feeds the heated fluid, under pressure, to the Isuzu heater core where the Isuzu heater works just as it did in the gas car. Return is back to the fluid container to be heated and recirculated.

The Electric Hot Water Heater Components (Heater, Mount, Contactor, Anderson SB-50 Connector, Fuse) comes in at $350.

The Power Pack Chargers.

We opted to carry the Power Pack Chargers with the EV instead of relying on destination facilities. With this decision, all we have to do, then, is to plug the EV into commonly available household sockets, either 110 volts or 220 volts. In our view, this was an absolute necessity as you don't have to depend upon any one or any entity to provide the charging facilities that might or might not be available in 2012.

We discussed and finally decided to put the chargers (two of them) up front where the gas motor radiator used to be. They would sit side by side on a platform (we make) and bolted to existing bolt holes found in the Isuzu chassis.

We started out with wood blocks but quickly changed to steel. Both chargers were heavy, wood was certainly out. We finally used the same steel material that we used for the electric motor mounts. We did this with the idea that we would ultimately replace the steel with aluminum. We have no pictures of this steel framed unit. To bad, because it was beautiful.

Mounted chargers.

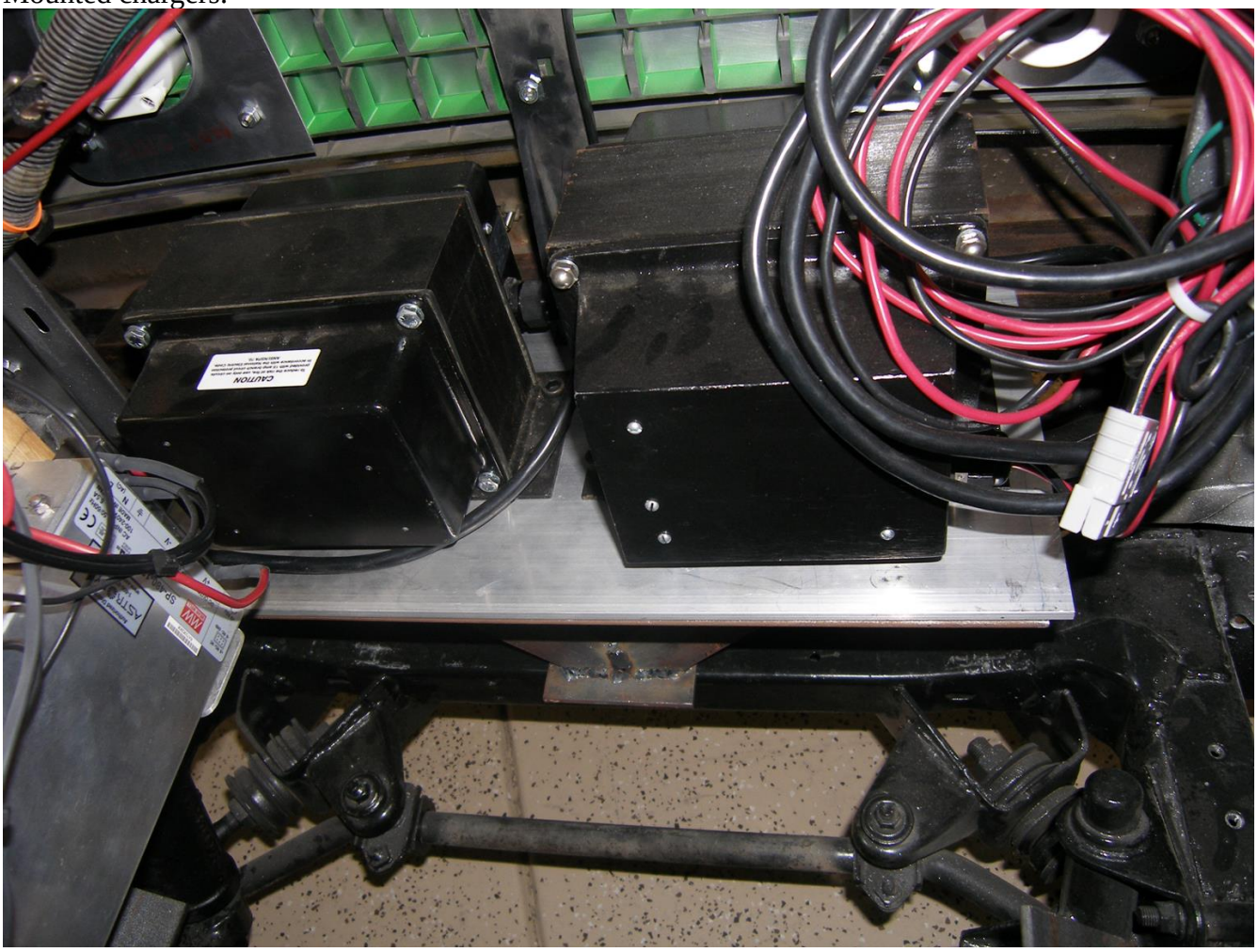

Figure 9 – 8 The 110 volt charger, shown left, 220 volt right.

The 220V charger priced out at $ 1,030. The 110V charger was a newly developed model and was discounted at $ 800. Both are Quick Charge units. The brand name Spec. of the 220V Charger is Zivan NG3 Charger 2800 watts, 230 VAC input, 144VDC output. Both about 50lb to 60lb each.

We ventured toward an RV store (not EV). We bought two exterior sockets, one for the 110-volt charger and one for the 220-volt charger. We installed both of these sockets in an aluminum panel that we made to replace the stock Isuzu plastic grill. Check out Figure 9 – 9. Each socket cost us about $80. each. (stay away from RV stores).

Besides the expense, we were pleased as quality high and they were designed to shed rainwater.

View of the front of the EV.

Charging sockets.

Figure 9 – 9 Mounted charging sockets

We felt the need.

Yes, we were happy to get this far, but felt the need for some really up-town charging cables, and, since the sockets came from an RV store, we obviously decided that an RV store would be the exact place to go to find extension cables. After all, they would certainly fit the RV sockets.

They certainly did have exactly what we wanted. They were also really pricy. But they were beautiful. They were yellow. Just like mustered on a hot dog. We really like lots of mustered on our hot dogs. We bought both. One for the 110-volt socket and one for the 220-volt socket.

We are still recovering from the price. What we're saying --- it's "buyer's remorse" at $300. each --- don't go there.

We do Power Brakes

We created this brake function as another compartmentalized unit (as per the “Keys”). We did this by gathering all the electric parts that are associated with the EV braking system and placing all of these parts on top of the left inner fender well. This position is located under the hood and directly in front of the driver. Note that all of these parts are positioned in a single line, colored silver-gray, and located upper right in Figure 9 - 10.

The EV braking system works just like the stock Isuzu braking system. Whereas the stock Isuzu system works by creating a vacuum from the action of the pistons in the gas motor, the EV system must create its own vacuum by using an electric vacuum pump. This is a dedicated unit which has an attached closed vacuum chamber, or plenum. The plenum is designed to hold a vacuum. The job of the vacuum pump is to keep a near constant vacuum in the vacuum chamber, or plenum, so that whenever the brake pedal is pressed, the vacuum in the plenum chamber will be available to operate the brakes.

The final part of the EV braking system is the Vacuum Switch. The Vacuum Switch is in front, which is located between the vacuum pump and the front of the car. The purpose of the Vacuum Switch is to control the function of the Brake Vacuum Pump.

The Vacuum pump and plenum chamber is a 12-volt unit and costs $225. (2008). the Vacuum Switch is $135. (2008).

The EV Final Design in place.

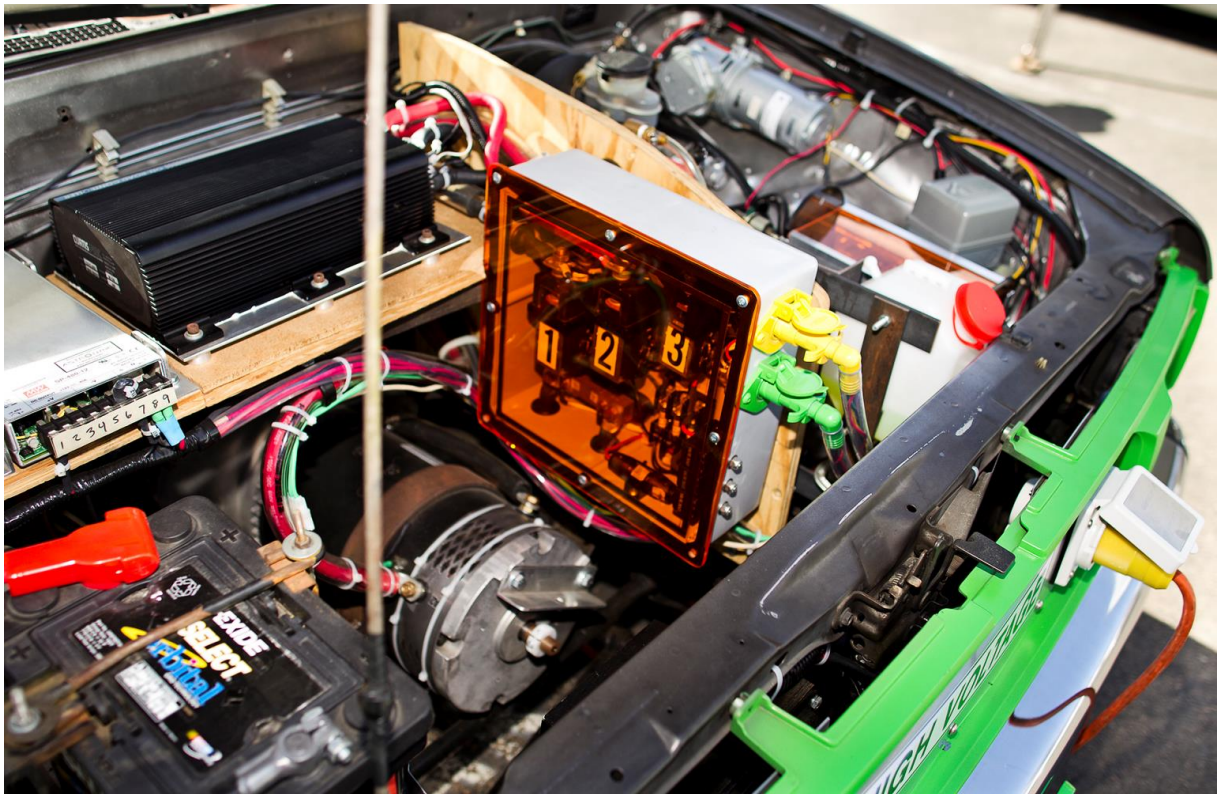

Figure 9 – 10 Power Brake System, upper right, silver-gray. (SMUD Event 2012)

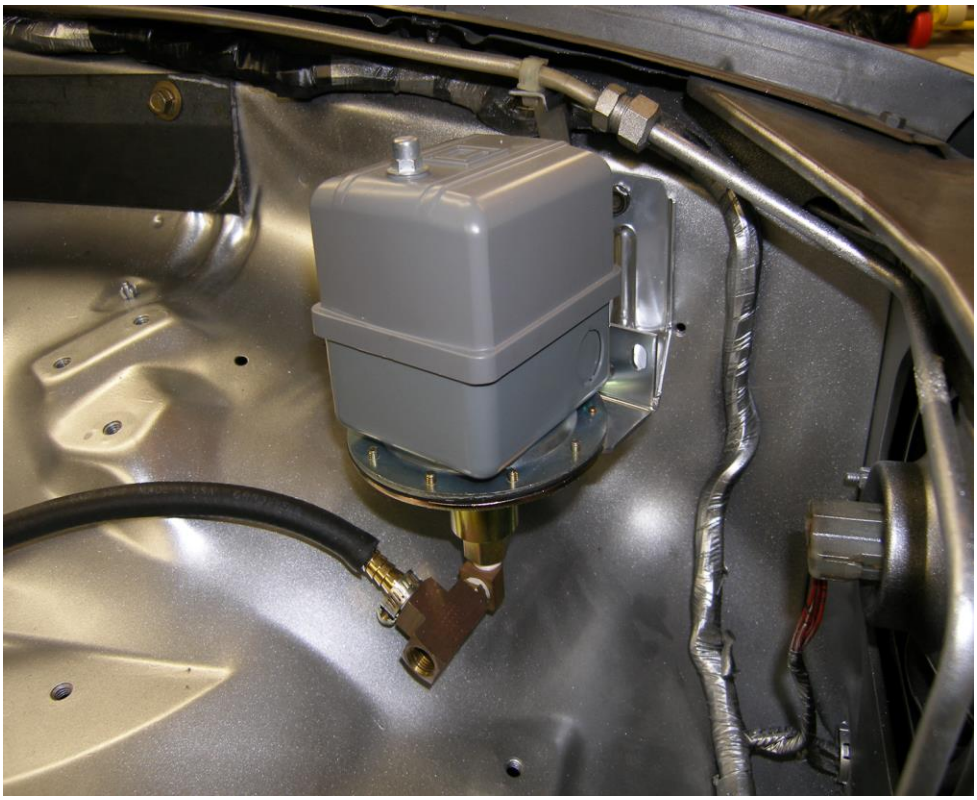

Figure 9 – 11 The Vacuum Switch prior to final connections.

Vacuum Pump with attached vacuum chamber

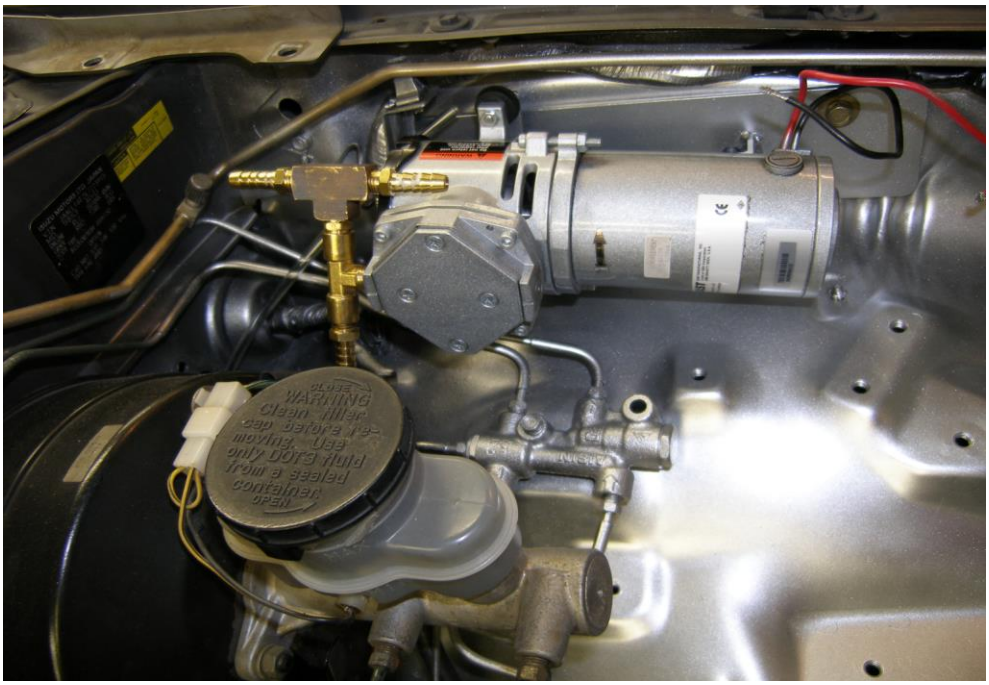

Figure 9 – 12 The Vacuum Pump with assembled brass vacuum parts ready for the rubber vacuum lines to be connected.

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Vacuum Pump installed

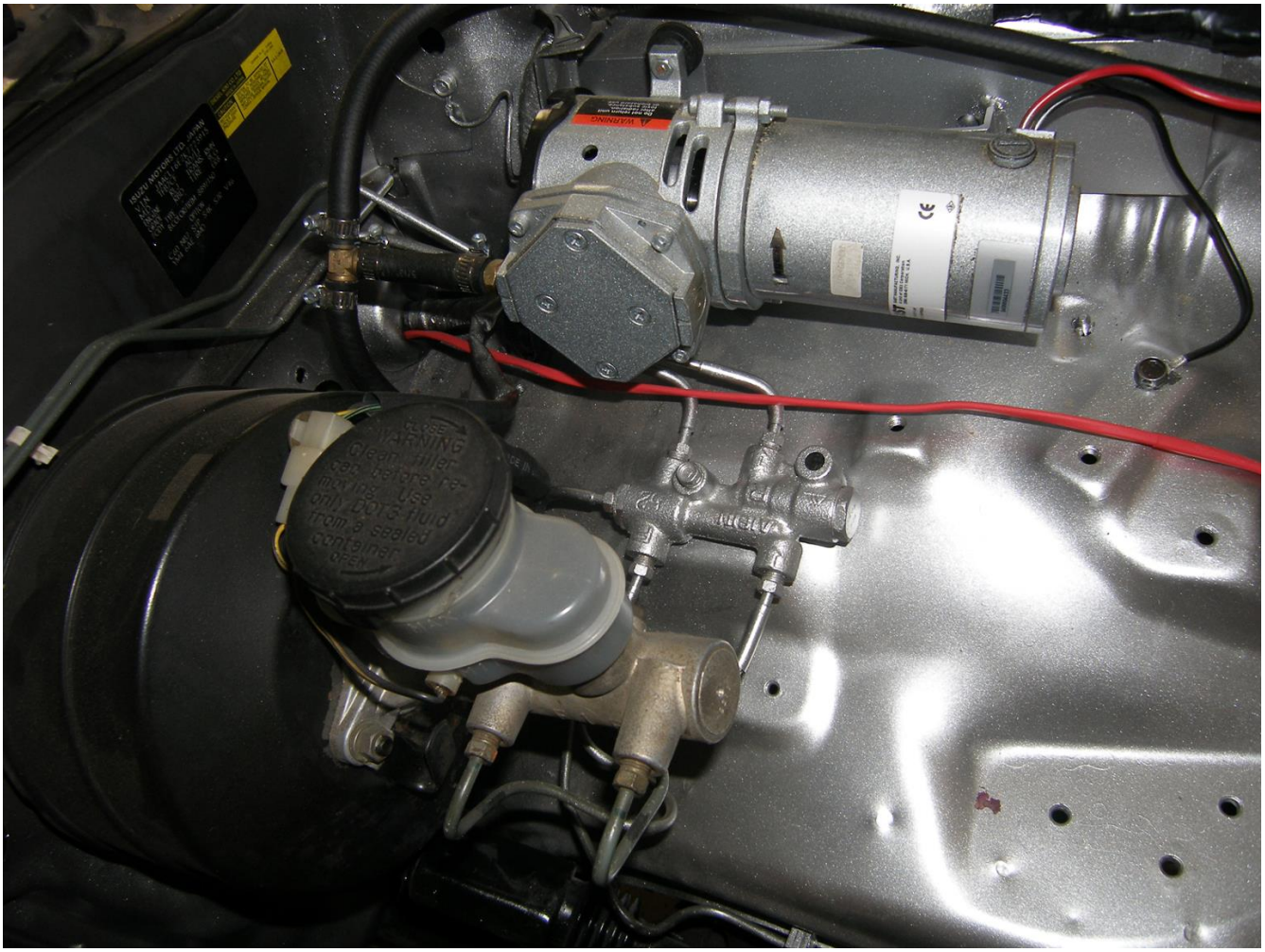

Figure 9 – 13 Vacuum Pump with fully connected EV braking system.

Note that the vacuum pump is located directly behind the octagon plate. The vacuum chamber (plenum) is attached and directly to the right of the vacuum pump motor. To the forefront of the picture is the stock Isuzu brake fluid reservoir and the hydraulic lines to the Isuzu braking system.

The EV Instrumentation.

We have four EV based readouts. These are the RPM, Voltage, Amperage, and Temperature. These readouts are arranged in the instrument “Cluster”(the green box), which is located in the EV cab and sitting on top of the Isuzu dashboard, See Figure 9 – 14.

We also have the usual speedometer reading located in the stock Isuzu instrument panel, in front of the steering wheel.

Cab of the EV

Figure 9 – 14 The stock Isuzu dashboard and instrument panel with the addition of the green EV instrument "Cluster" and the green gear shift lever and knob.

The "Cluster" readouts.

The RPM meter.

A 3" diam. Tachometer reads 0 -7000 rpm. Cost is about $187. Along with this is a magnetic pickup Tachometer Sender that is attached (by the purchaser) to the front of the motor face and picks off revolutions of the motor armature, Cost is about $106. Total cost about $293.

The Voltmeter.

A 2" round meter. 80 -180 Volts. The Voltmeter receives information from the Astrodyne Charger. Cost is $65.

The Ammeter.

A 2" round meter. 0 - 400 Amp. The Ammeter receives information from the "scary shunt". Cost of the Ammeter is $65.

Motor Temperature sensor location.

An over temperature light, not shown in Figure 9 – 14 or Figure 9 – 15 but later would be located bottom left of the green panel. The temperature sensor is built into the Advanced DC Motor frame and is connected to a light which turns on at a predetermined motor temperature.

Temp Access.

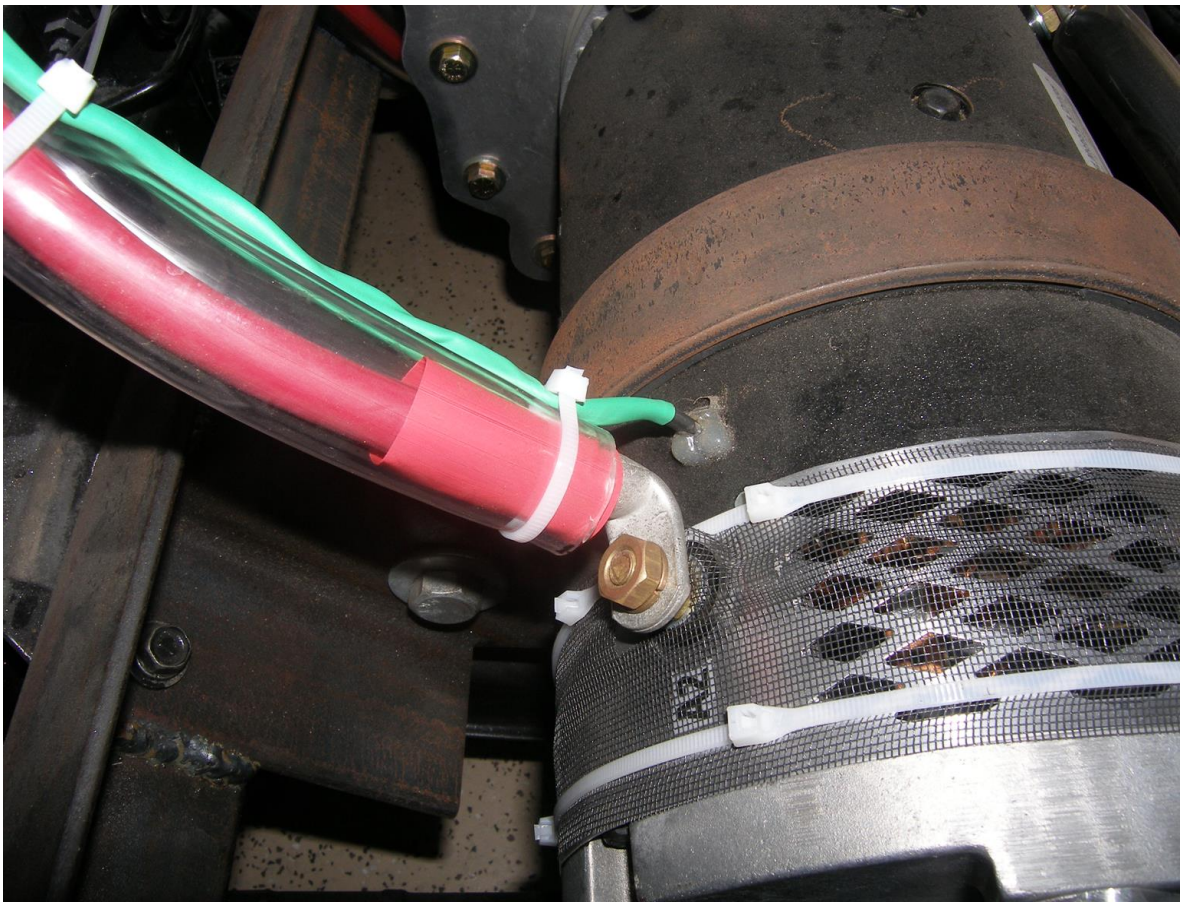

Figure 9 – 15 Temp. transducer located in the motor frame and wired at the factory (green wire).

It's the green wire (Figure above) that leads to the green instrument cluster and to an over temperature light indicator installed near the bottom of the green cluster. The installed over temperature light is not shown in any of our included pictures.

Notice the nylon mesh covering the cooling holes of the motor. This was furnished be the manufacture of the motor. We assembled all with appropriately sized Zip Ties.

Also notice the motor mark " A2 " , provided with the motor by the factory.

Instrument “cluster”

Figure 9 – 16 The handmade instrument “Cluster”.

Building the Instrument “Cluster”

The Essential Parts.

The cluster was hand built by gluing together three sections of 3” diameter PVC pipe. Regular PVC “Blue” glue was used. An auto-type resin was used to sculpt the transition between PVC tubes. The front face of the cluster is cut from an aluminum panel, 1/16 “ thick. (the three panel instruments were designed to fit into this type of panel).

The 2” and 3” diameter instrument holes were cut out of the front aluminum panel by using hole saws. Instruments were placed by the means provided by the instrument manufacture. The rear panel was cut from 1/4” thick exterior hard-pressed Masonite. The front panel, the three glued-together PVC tubes and the back panel were all held together like a sandwich via the two bolts. Shown are the two NyLock end nuts that, unfortunately, look like turn able knobs. We may have changed this arrangement when the Motor Over Temperature Light was installed. I can't recall.

The “Cluster” was fastened to a ¾ “ thick Mahogany board via one centrally located fastener. This allows the “Cluster” to rotate when sitting on top of the narrow Isuzu dashboard.
All materials and tools are readily available at home improvement stores. The cost of the material needed to make the green cluster is probably less than $10.00 --- labor not included.

On the Wiring Diagram, we elected to draw the Instrument “Cluster” as it appears. This is simple and makes much more sense to the viewer then representing it as a simple box --- besides we are pretty much proud of it and love it's sexy shape. (Yes, we are embarrassed.)

Instrument “Cluster”.

Figure 9 – 17 Three-quarter view of the Instrument “Cluster”.

The green cluster could be counted as part of the next topic , “Making Furniture” , but we have elected to reserve this topic description for larger items.

PART TEN --- MAKING “ FURNITURE ”

We cover the Trojans.

If you could pick them up by yourself, they would weigh 1800 lb. If you had $4,000 in your wallet, then you could take them home. If you had all of the previous, then you could produce 144 volts at 500 amp. That would, or could, toast your toast.

Another view --- our lyrical remembrances of the “not-so-pretty-box” --- sorry.

If you had all of these Trojans in your garage, then you would want to make them comfortable, give them their own room, you know, a box. Being that we were intimidated early on, that's what we did. Remember, back in Part Four, and not being of any particular merit of knowledge or any particular merit of wallet, our choice of box was not so pretty. That is exactly why we chose to call this particular box, the “not so pretty box”. We wanted to keep our Trojan “crew” comfortable and out of the weather, so we set about to make a roof, or cover, for our “not so pretty box” . Since our Trojan “crew” was not the most friendly of nature, we felt the need to keep them away from the most friendly of folk, so we tried to provide some protection for these most friendly of folk --- as to their fingers, being large or small --- out of “harm’s way” --- you know --- that's our job.

Another view --- trying some alternative thoughts.

We had ideas, which mostly swirled in and out of our heads. We thought about covers made of plastic or fiberglass. This material would be the most desirable, because of weatherproofing issues and conductivity issues. We wished for swing up truck bed covers --- the pop ups that suddenly flip up via air shocks. They're nice and neat and exactly what we need but they're too expensive. We're in the final throws of our project and running out of money. So, obviously, we turned, once again, to thoughts of wood.

For a brief moment, we thought about making our own pop up using a thin but reinforced plywood (alla old airplane style). But we're getting tired, and the mechanical complications were really too much for us to handle, we're tired. Yes, maybe “worn out “ might be a better description. I never thought that I would ever say that. So we opted for “simple”. Our inner brain pointed toward a flat, piece of plywood. We'll call it a “slider”.

Straight away, a very simple idea. It's just slides on --- or slides off. But, our inborn creative energies, would, in some way or somehow, tackle us, throw us down, and would not allow us to bow out of transforming this simple idea into something much more complicated --- it comes with the territory --- we love it, we can't help it --- so don't bother throwing us a life preserver.

<u>We make a “slider”.</u>

How can you make a flat piece of plywood more complicated? Easy. Give it to us. First of all, we thought about hinging it down the middle so it could swing left or right. This was OK but then we have to weatherproof the hinge, and, besides, swinging a large piece of plywood isn’t a very good idea, even in the best of conditions --- and , above all, it's not what we wanted, it's not a slider. We kept on saying, “simple”. Just one piece of plywood, simple. Slide it on or slide it off. It's a slider. We were convinced. The plywood slider would not be overly large, just large enough to cover the battery box. This was our final thought ---

<u>Not.</u>

Our final thought now escalated into increasing the width of the slider. If we did that, then the slider

would extend out to the entire width of the Isuzu bed. We went for this idea because this would aid in weather proofing the box. Otherwise, rain might collect around the inner fender wells and would surely compromise the box. The inner fender wells would now be covered by the slider. So far, so good. The plywood slider remains the same length, but the width would be about 24" wider. Still small enough and light weight enough to slide easily. That was good.

All we had to do was to manage to slide the plywood off the top of the battery box without having it fall off. To accomplish this, we chose to use guides to keep the slider on track. We made our own slider guides from found metal parts found in the garage. They would be fastened to the underside of the slider and would hook underneath the Isuzu's rolled bed edges. It worked.

Then the obvious idea popped --- we now have 12" of free space on either side of the Isuzu bed. In our view, this was sensational (complications are creeping). That 12" of free space was useable. It was a "no-brainer" situation, so "let's use it" (we said).

We make "Utility Cabinets".

The "no-brainer" turned out to be utility cabinets. One utility cabinet on either side of the plywood slider. The cabinets would occupy that 12" of free space and would fill the space on either side of the battery box. They would just be open boxes with no lids. The slider would act as their lids. When the slider is opened (slid back), the utility cabinets would be accessible. When the slider is closed, the cabinets would be closed. Simple.

We had a better idea. We could cut about 12" off of each the left and right sides of the plywood slider. These cut off pieces would now become cabinet lids and be attached to the slider by piano hinges. We could then access the utility cabinets without having to move the slider back. This is simple --- but bad things emerge.

We have a weight problem (excluding myself).

We're getting heavier in that we had to increase the thickness of the plywood to ¾ ". This increase in thickness is needed because the piano hinges that we will use to attach the lids to the slider must be edge mounted. For security reasons, the mounting screws for hinges must not be accessible when the lid is closed, which would be the case if the hinges were surface mounted.

In our case, another problem, edge mounting means having to put screws into the end grain of the plywood. This is never a good idea because of the possibility of delaminating the plywood. However, we could get around this problem by the carefully setting the hinge screws.

Note that there is a fine line between forcing the plywood laminations apart and setting the screw threads properly. What we lose in shear "pull out" power of the screws, we'll make up in the greater number of screws that are typical in piano hinges. If we balance this out, we're OK.

How to lock the slider.

Our bottom line is theft and safety. No fingers in bad places. What we have, so far, is a ¾ " thick piece of plywood sitting on top of the Isuzu bed rails with metal tracks that hook to the Isuzu bed rails. This arrangement allows the slider to move back and forth without falling off. However, what we really need is to find some way to lock the slider closed --- out of reach of danger and theft.

After massaging our brains, we decided to place a wooden frame underneath the slider. This would add about 1 ½ " of thickness between the truck bed rails and the slider. The newly added frame would then be attached securely to the bottom of the slider, except for the cabinet lids. They would rest on top of the wooden frame but would not be attached to it. This allows the lids to freely move (to open) but also allows the lids to be key locked to the wooden frame. In turn, the wooden frame is then attached to the battery box via simple removable pins or thumb latches that would be inside the lockable cabinets. Everything would be secure --- we're good. (I understand your pain)

The wooden frame under construction.

Figure 10 – 1 Introducing the wooden frame.

Most of the woodwork (construction of the "furniture") was done inside Dad's (my) garage. On the most part, the metal work was done at Mike's house. Figure 10 – 1 shows the woodwork in progress. Note that the "HAZMAT" window is laying on top of the slider, waiting to be cut into the plywood top.

By this time, the piano hinges have been installed (both sides of the truck) and the side lids have been cut into two lengths, a short one (rear) and a long one (front). Figure 10 - 1 shows this cut but it's difficult to see. Note that the mid piece of the frame has been installed and indicates where the long and short lids are separated.

We plane to lock the longer front cabinet and leave the rear cabinet open or accessible for emergency use for "first responders" . The long lockable cabinet lid on the right (passenger side) will house the outward connections for the potentially hazardous power cables. These are the cables that provide the power for the motor. This is obviously potentially dangerous so this side of the long cabinets will be locked most of the time, only opened when the slider is slid back for maintenance.

The long cabinet on the other (driver's) side will contain the various tools and gloves necessary when servicing the Power Pack Batteries. Both long cabinets will be lockable with a suitable key lock.

The short cabinet on the right (passenger side) will house a loop of the black 0/2 ground cable. If this cable is cut, the power pack will be isolated from the motor and all other related parts.

Note that the first thing that fire crews will do when approaching a wrecked car is to cut the ground cable of the car battery. What we're doing here is the same thing. First, we have to tell the fire crew that the power Pack Batteries, in the truck bed, exist. This can be done by creating a window in the top of the slider. Second, we'll tell them that the ground cable for this set of batteries is readily accessible without opening the Power Pack box. We do this by labeling the emergency cabinet.

Emergency labeling will be covered in Figure 10 - 6 .

The other side of the truck bed will see the same treatment. There will be a longer forward cabinet that will be lockable and a shorter rear cabinet that will remain openable. I say “openable” because we want a magnetic latch that takes a modest pressure to open the lid. The usual magnetic lock is fairly ease to open, as they should be. We wanted something that required more pressure.

Not finding a magnetic lock that met our criterion (harder to open), we designed a lock of our own. We chose a fairly strong horse-shoe magnet to keep the lid closed under most condition relating to curious people and children. It's positioned to be self-centering and works rather well. We'll keep it. Looking back, we probably should have tried two store bought magnetic latches per emergency lid instead of just one. This might have been a better and cheaper answer, but we will keep what we got. It works good.

Both short lids of the EV slider will share the same handmade magnetic lock. The content of one of these emergency cabinets will contain the ground loop of 0/2 black cable, as we described earlier. The other side, the left or driver's side, will contain an ABC fire extinguisher. An ABC fire extinguisher is capable of extinguishing all common fires, which includes electrical fires. The obvious choice.

This is the best that we could do. We wanted to make the equipment safe from unknowing fingers and we wanted to make the existing dangers obvious to anyone approaching the EV.

Another view of the slider with wooden frame attached.

Figure 10 – 2 Another view of the wooden frame.

This view of the slider shows the left (driver's) side opened. As before, the long lid and the short lid have been cut and separated but Figure 10 – 2 doesn't readily show this. Again, the placement of the short mid piece of the wooden frame indicates the separation between the long and short lids. Notice that there are strange looking scallops cut into the inner side frame of the longer cabinet frame. This is to provide air to the top of the battery box. We will discuss this later.

More weight.

Because of the addition of the wooden frame to the slider, the slider has gained weight. This could very well become a problem when the slider is at its maximum backward position (slid open all the way). We modified the slider rail hooks to compensate for the addition of the wooden frame to the slider. The rail hooks still worked well. But we were still concerned about the additional weight, so we looked for additional support --- we make a “ roll bar”.

The “roll bar”.

The “roll bar” is not a roll bar, it's a support bar. It just looks like a roll bar. The purpose of the support bar is to add more support to the slider when it's in its fully open position. Some may wonder

why we have it. It's just insurance. We have it, so we'll say a few words about it.

It's just a wooden rectangle made of 2" by 4" boards. It's sized to support the slider when the slider is in its fully extended position. We had choices. One was evident. One was not so evident. We could mount the bar on the floor of the bed near the back. This would push the support about 24 " back. The not so evident solution was to mount the bar on the top portion of the tailgate. With the tail gate open, the bar would just about double the support distance. We, obviously, chose the latter. Everything worked. Our intention was to convert the wooden support bar to aluminum. In addition, we dreamed about adding an aluminum deployable cage. This would add an aluminum expanded metal fence or cage to carry miscellaneous items in the back of the truck bed. This will wait for the future.

The stowed support bar.

Figure 10 – 3 View of the stowed support bar.

Figure 10 – 3 (above) Shows the EV with the slider in place, and the tail gate closed. Note that this view also allows you to see the separated lids. The front lids show the key locks in place (the smallish chrome " buttons"). The shorts lids give a hint as to why the cuts between the long lids and the short lids where not readily seen. Notice that the grain of the wood is continuous from one part to another. The reason for this is how our thought processes occurred. We stared out with a one-piece slider, then changed our minds. We added a lid to both sides of the slider. We changed our minds again and decided to cut the single lids into two lids. We did all this while the slider was sitting in

place.

The deployed support bar.

Figure 10 – 4 View of the deployed support bar with slider in open position.

In view of the fact that the slider was getting heavier, the thought (mine) was to rest its weight on something in case we later would like to put something on it, like a gallon (or several gallons) of water while we were watering (flooding) the batteries. That's the reason and I'm sticking with it.
The “out-of-the-box” part of this story was thinking that we could mount the bar on the tail gate. Doing this would extend the reach of the bar by about 20 “ .

We had other thoughts about this, like doing this whole thing in aluminum and designing a deployable expanded aluminum cage that would allow things to be carried in the back of the truck without the small light weight things from blowing away. This whole concept seemed like it might become a spin-of from the EV project and might be patentable. We'll leave this whole story here and take it up some later date.

Detail view of the deployed support bar (tail gate down) with slider remaining in closed position.

Figure 10 – 5 View of the deployed support bar.

Before we leave the slider, we felt the need to protect the plywood end grain from the weather. Our choice was to use hard wood end caps. We leaned toward using a contrasting dark mahogany. The caps would be about 1/2" by 3/4" . This size would be enough to completely cover the thickness of the plywood and leave enough mahogany showing to accent all of our hard work. We made the familiar trek to the home improvement store and picked out some choice dark mahogany. We used a good waterproof glue and plenty of 3" long stainless-steel sheet rock screws. Everything went well.

We communicate with the "Fire Crews".

We planned to do two things. First, we needed to let the fire crews know what the EV was carrying in its truck bed. That's the reason for the circular "HAZMAT" window. Second, we need to label the two emergency cabinets. These labels had to be self-explanatory, pictures --- no words. Words can be used, but not as a primary means of communication.

The following is our attempt at “no word” communication.

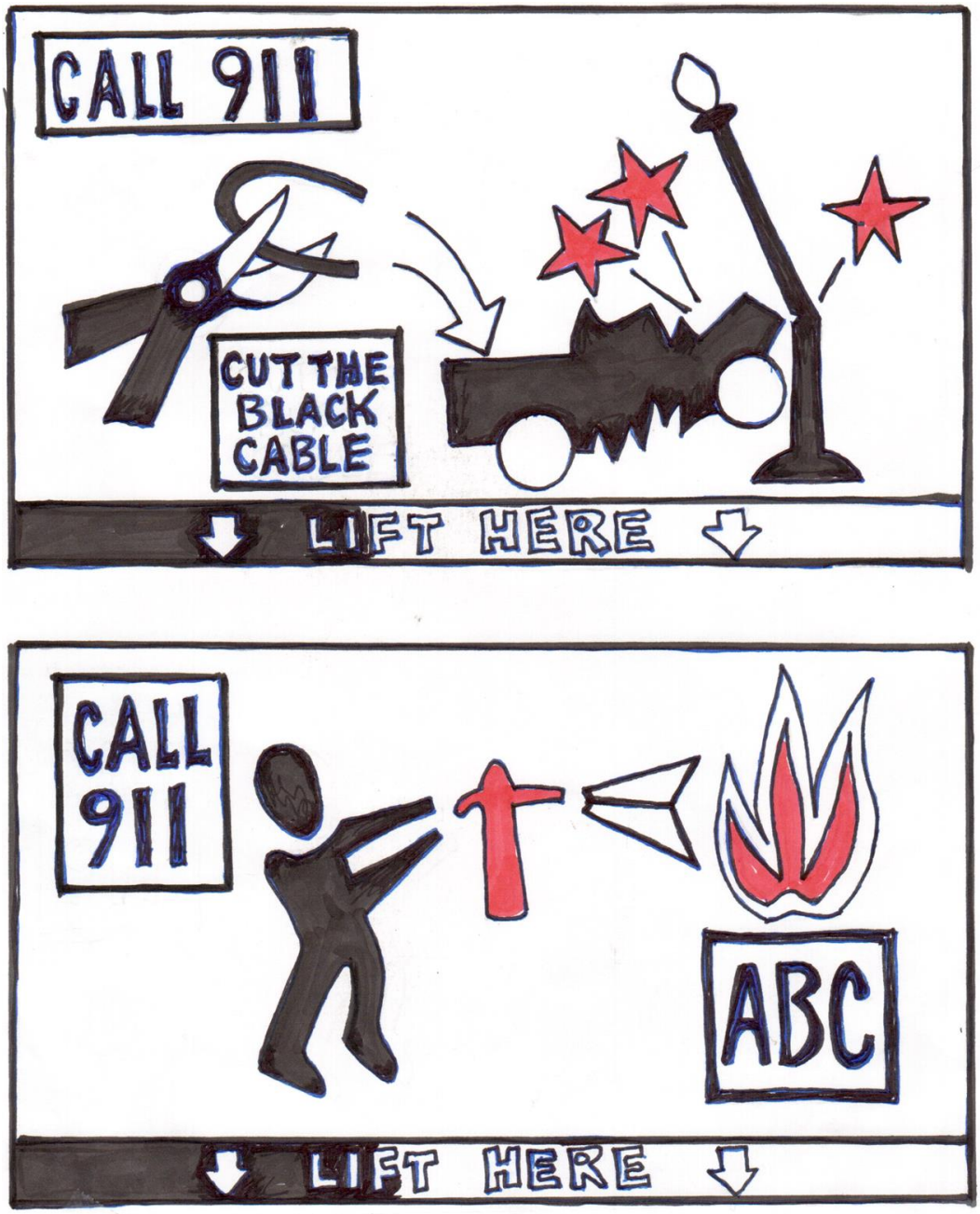

Figure 10 – 6 Emergency cabinet labels.

We make the “ HAZMAT ” Window.

We do it again for the fire crews --- a window to see what is inside the back end of the truck. We needed a large window to be effective for its purpose, but before determining its final size, we looked for an appropriate bezel. Having nothing at home, we headed straight for the surplus store. As luck would have it, we found a large, 24” square hazardous materials sign --- a “ HAZMAT ” sign. . We took it to my garage shop, found the sign's center, scribed two circles one inch apart, and cut out

our bezel, perfect. Couldn't be better. We did the same circle routine when cutting the window in the slider and the piece of ¼ " thick plastic and the closed cell gasket material (surplus). Everything went together with plenty of brand-new stainless-steel fasteners (surplus). Of course, we installed the bezel paint side up.

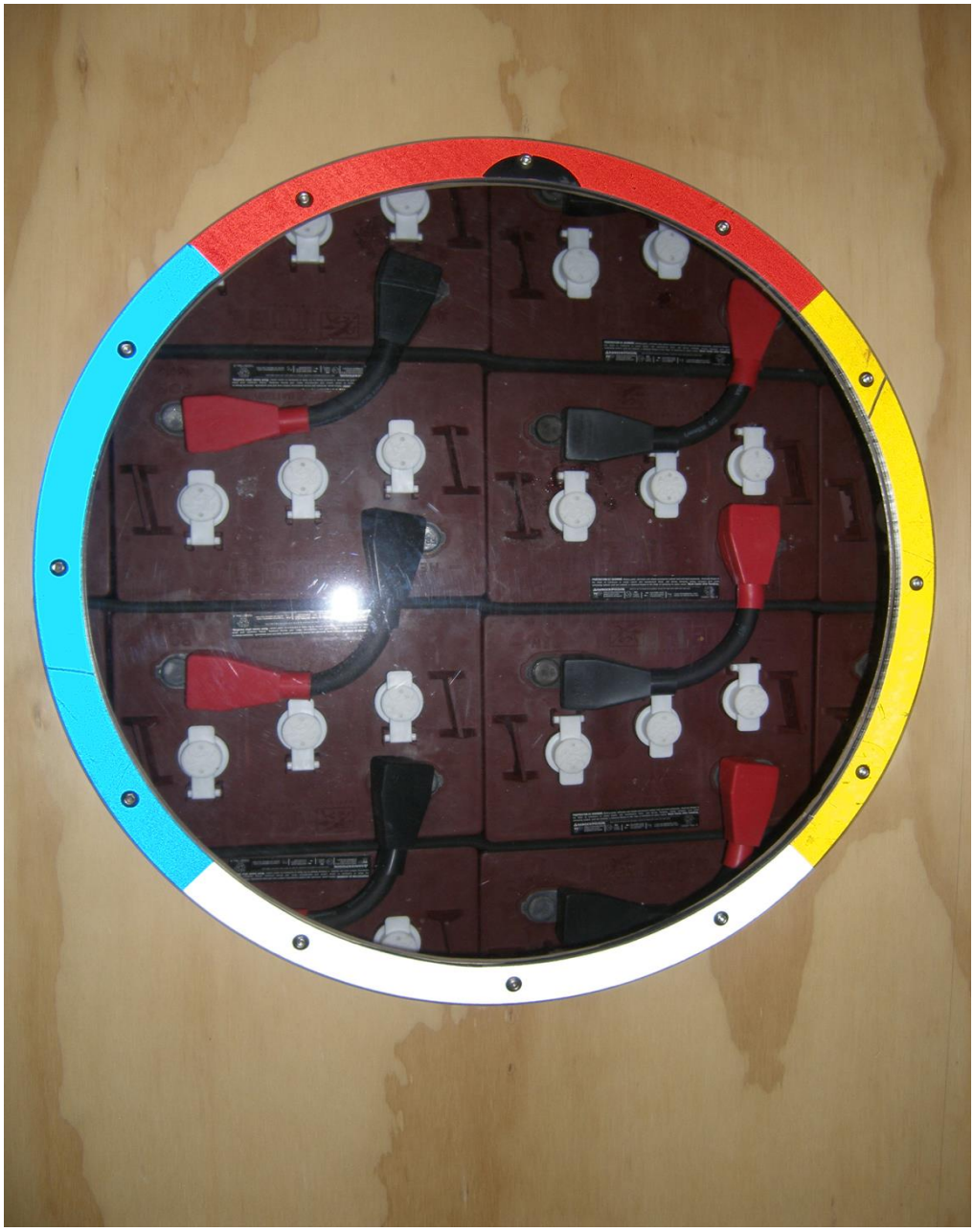

Figure 10 – 7 The HAZMAT window as set into the slider

The HAZMAT sign as retrieved from the metal surplus store minus the bezel ring.

Figure 10 – 8 The surplus "HAZMAT" sign after cutting the bezel out. Notice the top of the "2".

PART ELEVEN --- WE VENTILATE THE SYSTEM.

Dissipating Heat.

The primary source of heat is the Curtis Controller. It comes from the factory with an aluminum housing with extruded heat exchanger fins over most of its surface. The housing is black anodized for improved radiation cooling and it has a built-in fan that circulates air from the bottom. In addition, Curtis provides an aluminum plate and a tube of special contact cement that effectively transfers heat.

Per instructions, we glued the Curtis Controller to the aluminum plate with the special factory contact cement. On our own, we thru-bolted the Controller mount to the horizontal plywood table using ½ " aluminum stand offs. This raised the entire unit 1/2" above the plywood tabletop to increase the circulation of air over and around the unit.

The Curtis Controller.

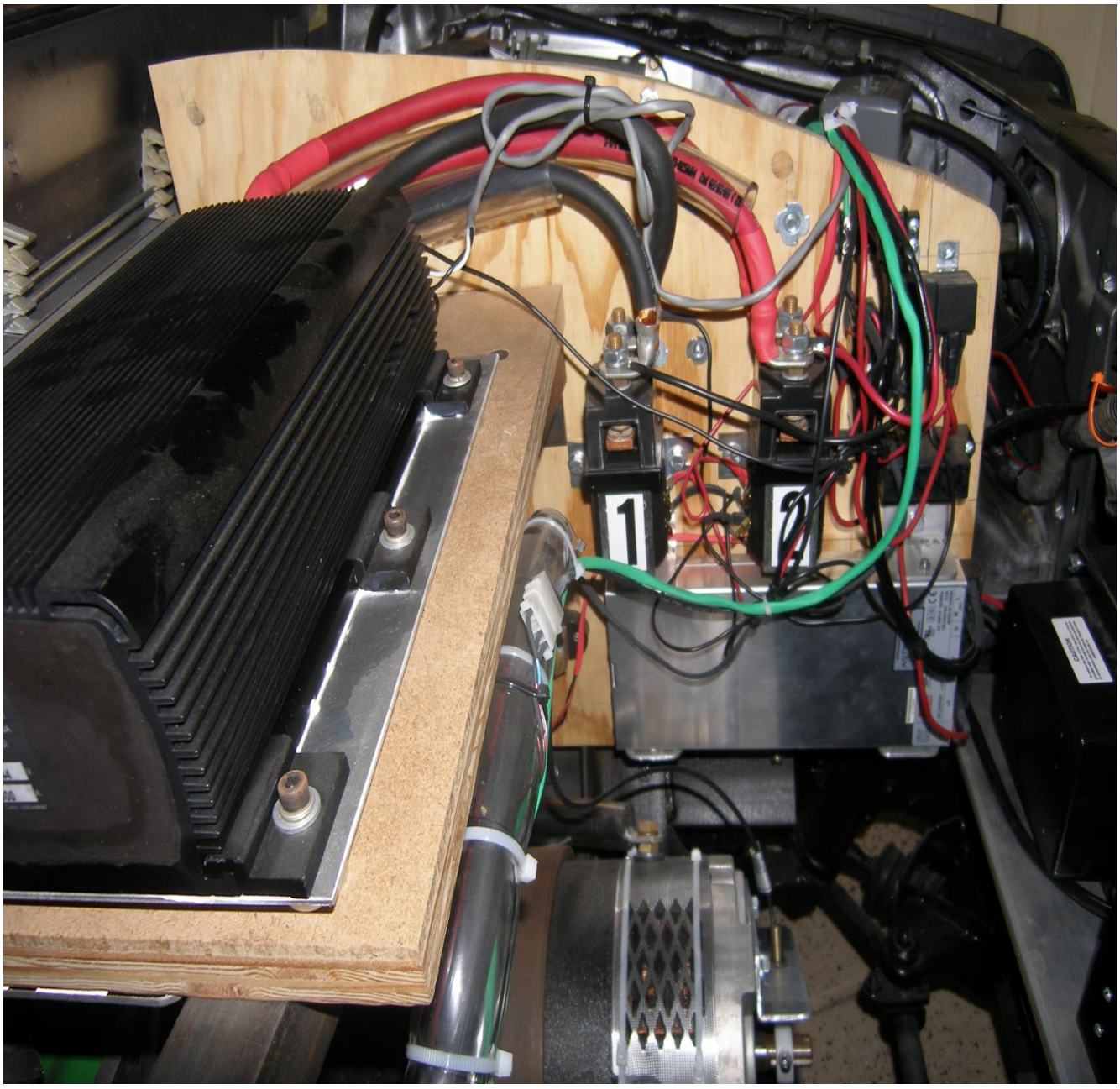

Figure 11 – 1 The Curtis Controller, left, black box. Shown glued to an aluminum heat sink and bolted to a plywood table with 1/2”aluminum standoffs.

The Controller still remains in the direct draft of cool air when the EV is moving. In the future, we intend to replace the entire plywood horizontal table --- top and support frame --- with a 3/8 “ thick aluminum plate and frame. This, we believe, will provide a very large and effective heat exchanger and heat sink.

This what we did. Referring to Figure 11 – 1, note the white line that outlines the circumference of the Controller. This is the squished-out contact cement that was provided by the factory. According to the factory, this white contact cement is heat conducting so it allows heat to pass directly from the bottom

of the Curtis Controller to the aluminum heat sink panel. The factory provides a fan which is connected to the bottom of the unit.

Dissipating Fumes.

The primary source of unhealthy and flammable fumes is sourced from the off gasses of the 24 Trojan Batteries. Off gassing largely occurs during the charging process, while the EV is standing, and, to a lesser extent, while the EV is moving. We have to design a system that rids the EV of these gasses while the EV is either parked or moving.

There are two types of air circulating processes. These processes may be categorized as either “active” or “passive”. The “active” type is produced by either forced air fans or the act of driving. The “passive” type relies on the draft of the natural circulation of air when hot air rises and is replaced by cold air. In our case, both processes are used in any way that provides adequate air circulation.

When we built the battery box, we didn't bother thinking about venting the batteries. The battery box had no lid. The batteries were open to the outside atmosphere. When we built the plywood slider, we didn't think about it either. When we added the frame beneath the slider, same thing. At that point, the plywood slider and frame effectively closed off the batteries from the outside atmosphere, bad news.

In this case, the batteries would see only the inside atmosphere, which could be an explosive mixture of ready to ignite fumes if provided a source of ignition (an electrical spark). We were lucky that nothing happened. We checked with the old reliable www.evalbum.com and found that things did happen. We were lucky.

We started with the lid. We decided upon a mix of passive and active circulation. We had to open up the lid to the outside air --- but still keep the batteries out of the weather and away from curious fingers. Remember, when we were forced to install the wooden frame underneath the plywood slider, we we're not happy. It was more weight and complications. Now it comes in handy.

The only way we could open up the slider to the outside air without making holes in the plywood cover was to make holes in the wooden frame, which is beneath and attached to the plywood cover. This would allow the air to pass in and out of the battery box. But, in order to maintain the structural integrity of the wooden frame, we made “partial” holes --- or scallops. The scallops were open to the outside air but not to curious fingers because of the lockable utility cabinets. See, it all works out.

A pause for trivia.

In the following picture, note the full-length stainless-steel piano hinge. We installed the hinge, then cut it plus the wood while the lid was still on the slider. Everything was intact and all worked perfectly. The cut is there but you can hardly see it. Hint --- only the top part of the hinge was cut.

Slider showing three scallops.

Figure 11 – 2 Slider showing three scallops cut into the forward section of the wooden frame.

But not so fast. The scallops were open to the outside air, but only to the “outside air” air that was inside the utility cabinets. In order to make this design work, we then have to open up the utility cabinets to reach the “real” outside air. This we did by the use of tubes. We chose to use 4” square PVC tubes (round tubes would work also).

So where do we get 4” square PVC tubes? They're from the usual home improvement store and are part of some decorative fence material (like a decorative white fence, just for show, in front of your house).

Given this material, we traced a pattern on the metal floor of the truck bed and cut a square hole to receive our square tube. We could then slip the square tube through the newly made square hole and

duct the 4 “ tube from inside the utility cabinet, down and out of the bottom of the Isuzu chassis. This makes the openings unavailable to outside pedestrian traffic. We then slabbed off the bottom of the 4 “ square tube to act like a scoop to pick up the air flowing under the car as it moves. Here are a few views of the 4” square tube as it extends down to reach underneath the Isuzu chassis.

Views of the square tube as it passes through the Isuzu body panels and chassis.

Figure 11 – 3 The chassis cut.

Figure 11 – 4 The scoop cut.

We're doing fine but we aren't done yet. We still need a sufficient amount of air entering the battery box even when the car is not moving. We need a fan.

According to EVA, any fan that we might use in the vicinity of the batteries must be brushless. For example, your electric drill uses a motor that uses brushes. In which case, there's several conducting metallic brushes that sweep the surface of the electric motor's commutator. If you turn on your electric drill and look into the rear most portion of the motor, you will, no doubt, see sparks. Sparks are not good in the presences of battery off gasses. As EVA said, we go brushless.

So that's next. We look for brushless fans. In fact we need several additional fans for other unknown places that we anticipate are waiting for us to discover. We visit the surplus stores. We needed 12 V D.C., brush-less fans, about 4 “ Diam.. Fortunately, these are the type commonly used in computer applications, where sparking is not good nor desired. That is definitely us. We were lucky. We found exactly what we were looking for. We couldn't believe it, five dollars each including finger guards. We were happy and suddenly we were out and down the block with a sack full of fans.
We have no picture of a brushless fan sitting on the table by itself, but we do have a picture installed, here it is (with proof of purchase).

4” brushless fan, installed

Figure 11 - 5 Installation of a 4 “ brushless fan with grill attached.

We get serious. We commence to make our first “active” system. We need to pull air out of our newly placed 4” square tube. We will do this by placing the fan some place inside the utility cabinet. A “no brainer”, the fan would be sitting on top of the 4” square tube. Sweet, we like it.

The next is another running of Apollo 13. We have a fan with a 4”round exit that must be mated to a 4” square tube. It wasn't planed, it just happened. We ran our usually trip to the home improvement stores and found the answer sitting on the shelf in the electrical department. It was a metal junction box with a round opening on one side and a square opening on the other.

Check out Figure 11 – 5. There it is in living bright galvanized metal. We're good. The junction box

even had attachment arms that were conveniently used on the wood 2”x 4” of the battery box (everything is somehow attached to the “not-so-pretty” battery box). Next are a few pictures of the fan installed in final configuration.

Detail of final fan installation in the utility cabinet.

Figure 11 – 6 Final installation.

To the upper right of Figure 11 – 6 , note the two pieces of angle iron. This is how ye secure the slider. All it takes is a simple pin through the matching holes in the angle iron pieces to keep the slider from sliding open. The iron pieces are secure from the outside by locking the cabinet doors.

Fan with scallop access to the battery box.

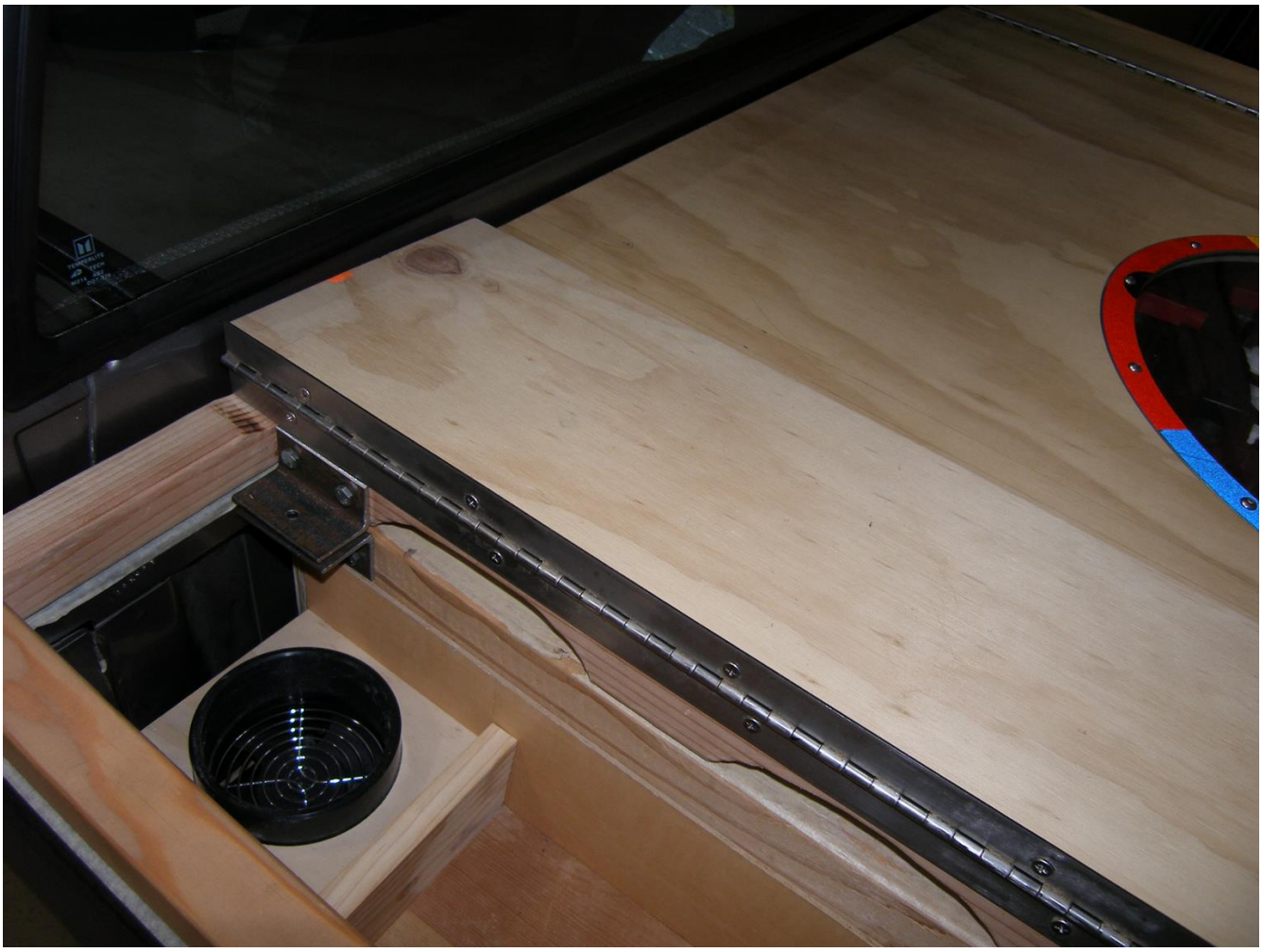

Figure 11 – 7 Fan with utility cabinet open showing two scallops.

Now this is the time to start dropping the word “plenum”. A “plenum” is a closed container that collects or maintains a positive pressure. At this point, the closed utility cabinet is now a plenum. The positive pressure inside the closed utility cabinet occurs as a consequence of either the fan operating or the scoop underneath the Isuzu chassis collecting air and ramming it into the utility box as the EV is driven down the road.

Either one of these circumstances will do the job of forcing air into the plenum chamber (the utility box). And, in turn, this rammed air is forced into the battery box through the scallops cut into the wooden frame. See how this works, everybody is “ holding hands”. The battery box is now under pressure and we need to exit this air, either actively or passively, or both.

The ventilation system is almost complete. Remaining is exiting the air above the batteries. We think that everything actually has a good chance of working. On one small part, we have proof. During our travels to or from Mike's house to my house, we forgot to lock the forward utility cabinet. That's the one shown in Figure 11 – 7. When we left, it was closed but not locked. When we arrived at our destination, it was open, exactly as you see it in Figure 11 – 7. We noticed it and wondered. Trying it again gave the same results. We were satisfied, the passive air collected by the 4”square scoop rammed in enough air to pressure the lid open. The plenum works and is not dumb science (as one

might have surmised since it came from the EV cowboys).

“Passive” works, now we finish the job.

We estimated that we needed three more of those 4” Diam fans to evacuate the air above the batteries. One in the center of the box and one in each of the corners to evacuate possible trapped fumes in the corners of the battery box.

So we cut three 4 “ Diam access holes through the end wall of the battery box. Holes of this size, to us, were not desirable as we were concerned about opening the battery box to weather and other bad things. But this concern did not last long. The holes went through 3/4” thick plywood and also through the vinyl liner that we had cut and installed in the back of the Isuzu bed. In addition, the fans, themselves, would be in place plus their grill guards. All of this seemed like everything would be, weather wise and safety wise, OK.

This was exciting.

We aren't through yet. The fan installations were done but we weren't done. We felt that we really needed fan shrouds to complete the installations, especially for the fans mounted through the vinyl bed liner. We went through the normal routine of hunting and browsing. Nothing found, nothing affordable.

We decided on a creative approach.

We headed for one of our home improvement stores, as the wide variety of “things” were more than most. “Intended use” was set aside, nothing was counted out. We leaned toward PVC, but we were open to anything. We wanted fan shrouds to fit 4” Diam fans. No use asking the store clerks. We just walked up and down the aisle until the store help started to look at us funny.

We weren't intimidated.

We threw several items in our pushcart, thinking that this might take the pressure off of our strange behavior. We ended up in the plumbing department. In the toilet plumbing section. We actually found the perfect fan shroud. It was exactly 4” inside diameter and black PVC. What else could you ask for. It was everything we wanted. It even had an out of sight mounting system and an extended 4” Diam. collar that would extend past our fan grill mount. It was perfect and the cost was more than reasonable at about $3.00 each. But the home improvement store didn't call them fan shrouds, as we knew they should, they insisted upon calling them toilet flanges.

We were flushed with excitement.

This may be a little embarrassing --- but we have pictures.

Figure 11 – 8 Inside diameter is 4 inches with mounting flange. Thank you Sioux Chief.

Figure 11 – 9 $2.98 plus tax.

As we said, we were flushed with excitement. The old man was happy. We mounted all the fans with the “shrouds”. We were more than pleased because it made us look like we knew what we were doing.

Detail of fan installation showing grill and shroud (toilet flange).

Figure 11 – 10 Detail installation showing grill and shroud but no fan.

The fan in the picture above is located in the back of the battery box and is cut through the Isuzu bed liner. As you can see, the fan has not been installed at the time this picture was taken. The fan shroud (toilet flange) fits nicely and blends into the truck bed liner.

The following picture shows the three fans in the back of the battery box. We have been accused of having three after burners installed in the trunk --- it looks like it , so we usually play along.

In real life, the three fans will evacuate the off gases of the charging battery pack.

The “after burners”

Figure 11 – 11 All three fans in place with tailgate down.

PART TWELVE --- THE “ FIRST TOUCH ”.

Much later.....

We're done but not all the way done --- we need to make our EV legal. In other words, we need to make another run, but this time, not to the usual “where-they-know-our-first-names” surplus store, but to the dreadful and scary DMV (where they don't care about your first name).

The first “touch”.

Remember, some time back when we were talking about that “scary shunt”, which we said looked like something, if touched, might hurt you. Well, this is almost the same thing. Mike initiated the first contact (the first “touch”). He walked into the DMV office about some other business and, offhandedly

mentioned the EV. Nothing happened. They smiled and gave him some paperwork which included type written instructions on where to go and who to see (the vehicle referee). The instructions went something like this ---

"Go westbound on AAA Street to the intersection of AAA and BBB Streets. Turn left on BBB Street. Go south on BBB Street to CCC Street. Turn left on CCC Street. Proceed down CCC Street to the third driveway on the right. Enter the driveway and proceed until the seventh aisle. Turn left into the seventh aisle and proceed to the 25th parking spot on your right. Park your car in the designated parking stall. Go into room 123. Pick up the phone and dial xxx. Ask for Mr. Doe or leave a message, your name and time."

I'm not making this up.

In our view, this was a little intimidating, so we made a "dry-run" with our gas car. We carefully followed directions up and until calling "Mr. Doe". Our "unknown" location turned out to be the parking lot of a local state college. In fact, it was next door to where Mike had attended some classes, years before. We felt pretty good at this point.

We drive the EV for real.

Next day we drove the EV to that 25th parking stall, found room 123, located the phone and dialed xxx. Mr. Doe, not being in, we left a message, sat down, and waited. The small room was empty except for a young man (maybe a student) sitting across from us. He was visually sweating. (I'm not making this up.) We talked with the young man. Evidently he was waiting for the referee to come back with his car. The referee came back. The young man left the room, talked to the referee and left in the car (I don't know the details).

The referee.

Our turn. We explained why we were there, gave Mr. Doe the DMV papers and opened the hood. He walked around the car, looked inside the EV and studied our handy work under the hood. He smiled, signed the papers and told us to go back to DMV. We left.

We felt good. Our original plan was to put off until tomorrow the visit to the DMV. The referee visit was enough mental anguish for one day, but we were riding a wave. Simultaneously, both Mike and I decided to go straight for the DMV. We had time. Worried yes, but it would be worse tomorrow. Get it over with.

We drove into the DMV parking lot, found the designated stall for vehicle inspections and popped the hood (opening the hood signals the DMV people that we're waiting for an inspection). We had papers in hand. Some young lady came out, looked at our papers, looked at the EV, turned around walked back into the DMV office. Out came the young lady with an older lady. They did the same thing.

They walked back in. Out came somebody else with other people in tow and did the same thing.

The "indifferent glances".

Out came a man with a few other people (I lost track). The man took a few indifferent glances, signed some papers and walked back in. We later found out that the man was the DMV lawyer. I can't remember much more, other than by this time we had a number of people (the regular kind) walking around and asking questions. We smiled a lot until our jaws hurt. We finally got in the EV and drove back to my garage, plugged in the EV, and Mike took off for home in his gas car. Done deal.

Months later.

It took about six months until we received the real registration certificate --- the one that listed the car as an "E". Mike insisted that the EV be listed as an all-electric rather than a hybrid --- which they wanted to do. I'm guessing that they had to re-write some software for the all-electric. We assume that the paperwork might have been much easier for them just to shuffle the EV off as a hybrid. But no, due to our insistence, we waited several months for the correct registration to arrive at Mike's mailbox.

PART THIRTEEN --- AFTER.

After the DMV --- after the referee --- after the registration --- our anguish was slowly dissolving. Looking back, we realized that we had just "sweet spotted" four years straight. We're done. It was an emotional void --- adjustment was there, but slow.

The real reason that we started the MYEV2 project was to get Mike to work without gas, so we did it. Mike went to work without gas, but not without me tailing him all the way. It was about 30 miles. This happened only for the first few times, or until we were both satisfied that the EV was reliable.

We soon found the freeway. It was the speed limit. We could keep up with traffic. The one thing we were slow on was acceleration. You can credit that on the EV's weight. At 5000 lbs. we were heavy. Another thing, the gear shifting. Without a clutch one must have patience, no speed shifting --- but we didn't promise acceleration --- just to travel down the road at 60 mph with no gas.

We test the waters.

We approached the city. We admit that we were timid. Remember, this was when no all-electric cars were on the highway. I guess the city was timid also. They greeted us with open arms. Everything was free. Parking in the City garages was free, and the battery charging was free. We just had to find the correct household socket to plug into.

PART FOURTEEN --- OUR " CELEBRITY " .

Our city newspaper rejected us outright. "What's your gimmick", the editor asked --- I really couldn't answer. To me, it was obvious. But to the editor --- it was nothing. So I said, " thank you" and completed the conversation with the editor's desk. Inferring from the six months it took us to receive our "E" registration from the DMV, I figured that we might just be the first to request that "E" plate in the Sacramento area, or, maybe even in the State. Like as before, we move on.

In the ensuing months, we would move the EV back and forth from my garage to Mike's garage for various jobs. On one of my trips to Mike's house, I happened to notice what appeared to be a very large party in the neighborhood park. It turned out to be the local city's " Celebrate the Earth Festival" or "Green Day". I had just finished putting a green stripe down the center of the EV --- so I stopped. The EV would fit right in. I asked if I could just park the car in one of the nearby parking slots --- "yes" was the answer. I called Mike and we were swamped with curious onlookers for the remainder of the day. We were right --- the paper was wrong --- the EV was a celebrity.

This continued for the next three years. By this time, we were even asked to bring our EV to various shows. Most of the time we agreed. Some we couldn't as some shows were out of range of our EV. We decided we needed alternative transportation --- behind Mike's truck.

<u>The Tow Bar.</u>

Years before I bought a tow bar for some reason I can't remember. I dug it out of the garage. Max tow was 5000 lb. The EV weighed in at 5000 lb., perfect. Installation wasn't simple, but we persevered until it was done. Looked good, worked even better.

Figure 14 – 1 The finished tow bar.

Detail.

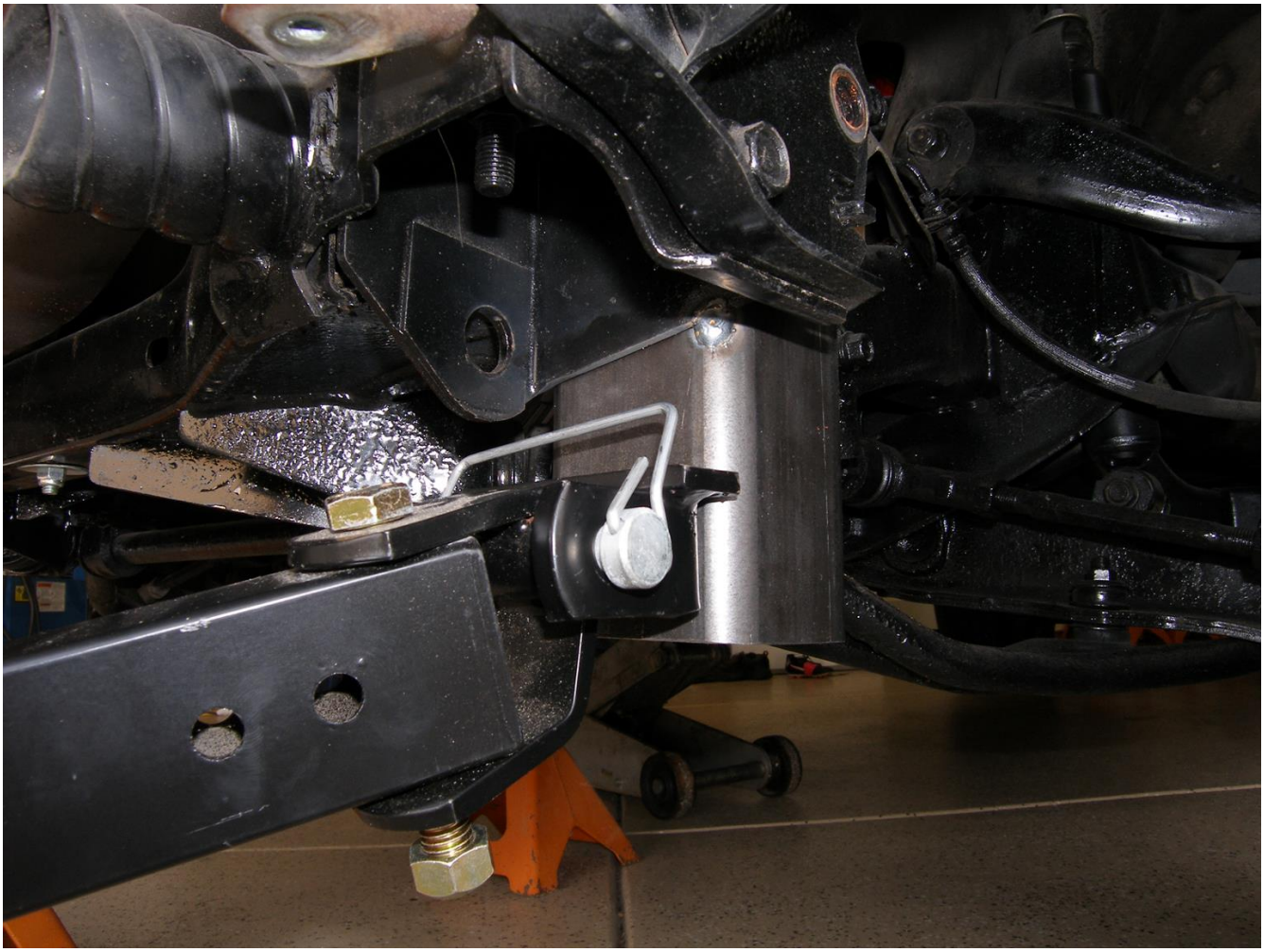

Figure 14 – 2 Detail of the work prior to full weld.

In no way was our tow design not going to work --- that was our thought going in and our thought going out. We wanted absolute confidence. We got it. As usual, we went slow over humps or bumps, but the tow was flawless.

We used 2 1/2" square steel tube with a ¼ "thick wall. Cut a short piece (about 6") and found a good solid location on the Isuzu chassis. We used a combination of bolts and weld. I was not going to fail.

We chose a tow hitch that allowed the bar to ride in a neutral position and without hitting the pavement going up or down Mike's driveway. It worked.

The tow design allowed us to take the EV out of town for car shows and participate in a "green day" parade at one of our State Universities. We were thrilled and the students were impressed almost as much as we were impressed with the students. I'm an old guy and I kept on saying to them --- do your dreams now, don't wait. Now is the time.

We stayed at the University event until nightfall and tested out our newly installed trailer lights on the drive home. We were happy. Our "Celebrity" was getting bigger and professional.

Our next stop was the north state's Electric Municipal Utility District. The big guys with the “AMPS” actually requested our little “Celebrity” to participate in its own “Green Day” show.

Being the littlest of the little “smuggions” we were delighted. We were happy and amazed that they even recognized us, though they did see us at one of the local “green” shows. By this time, “E” was “hot” --- the car industry was catching up. Big names and big prices were out there and coming to the Utility's “Green Day” show.

We were little. We were simple and we were cheap --- in a word, we were the “cowboys” of the show. Nobody like us would be there. So I dressed the part and went to work. It was a great show. We were thanked and we thanked them for allowing us to be present our work alongside the $200,000 plus “E” cars of amazing electrical sophistication. We were impressed.

The “cowboys” at the Utility show.

Figure 14 – 3 The “cowboy” working his best. Mike, on the other side, explaining the AMPS. (SMUD event)

Figure 14 – 3 Contemplation is always good. (SMUD event)

Figure 14 – 4 Notice the $200,000 beautiful EV behind us. (SMUD event)

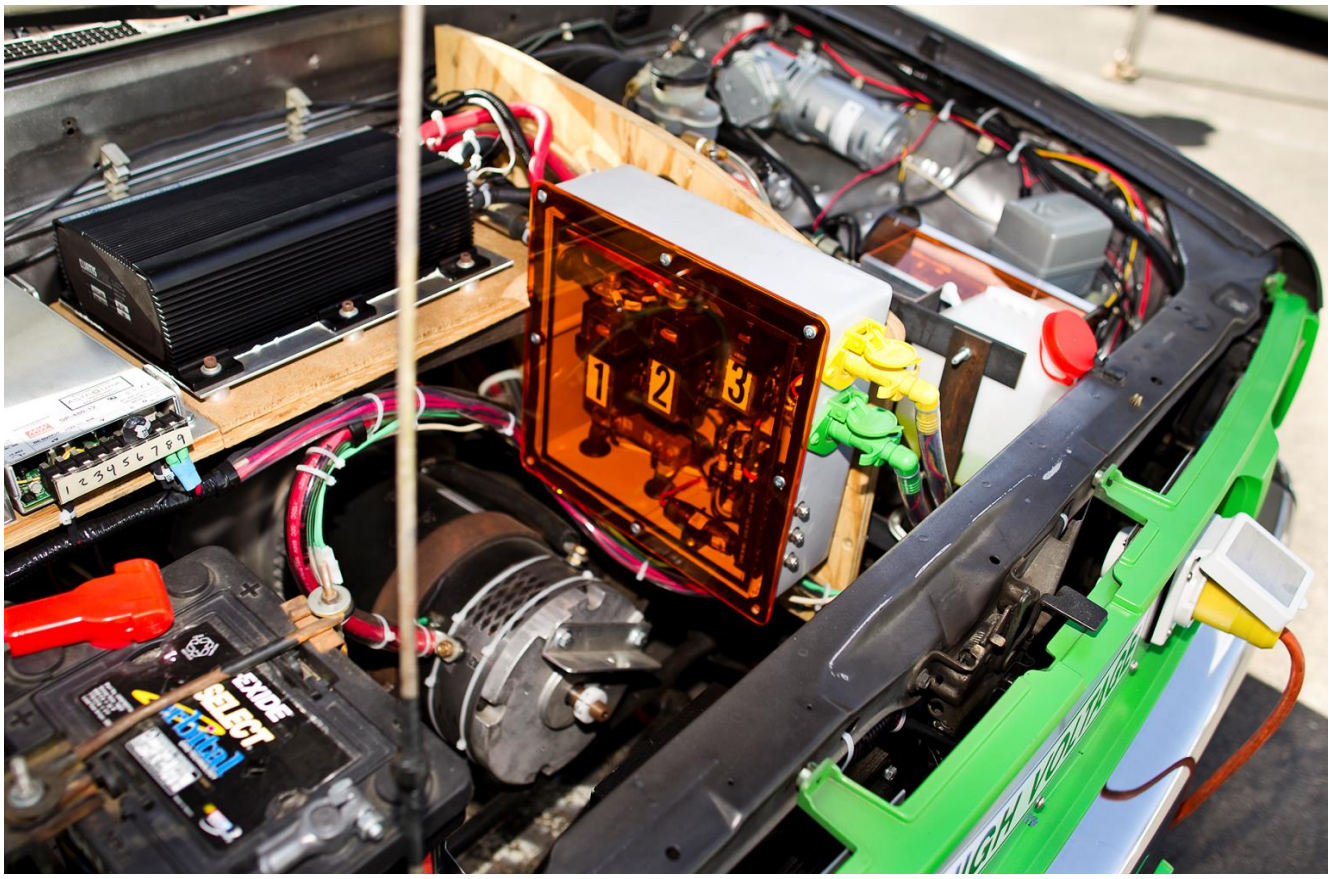

Figure 14 – 5 We made it happen. (SMUD event)

PART FIFTEEN --- WE STOP.

Yes, we stop. Amazing. We stop. It's hard for me to say, but that's what we did. We were absolutely burned out. Our drive and ambition were there, but our muscles would not respond. We were flat and we could not get up.

Mike's first love of "E" cars persisted but the "Wilbur and Orville" that we relished so much was unable to respond. He bought one. One of the first and one of the best, an all-electric LEAF. It's similar to the one that shared our first show location at one of our favorite "green" Shows. Mike's LEAF is pearl white and beautiful with great sophistication.

The LEAF is certainly over my head --- but what isn't. Until recently, I drove our "E" car as a daily driver. It was my "horse". This is how it's done --- you use it --- you bring it home --- you put a blanket on it --- and you feed it --- and you water it (if it wants a drink). What more can you say --- other than you do it over and over again. This keeps up the very next day --- the next day --- and more. It's my "horse".

PART SIXTEEN --- MY "HORSE" IS GONE.

I'm knocking on the that 80-yr. old door. Mike is up to his ears with work and family. My driveway has five cars on it. What more can I say. For several months now, we have been looking for someone with the appropriate knowledge to carry on our experiment. No one with that specialized knowledge or passion has passed the test.

We found a place and a person.

We gave our "Lady" (she's no longer our "Baby") to a
specialized high school. Ideal for the purpose. The place and person, the teacher, meets our criteria perfectly. This story has a happy ending.

The annual car show at "our" high school.

Figure 16 – 1 The Last picture at the car show.

No, this is not really the last picture. We have to get both Mike and me into the "last" picture. But, since the high school has a car show only once a year --- we have to wait another year for the both of us to appear in the same picture. Stay tuned. (proof that we never plan anything)
In the meantime,

Thanks for listening ..... the "Sweet Spot" cowboys.