Shay Electrical Part I - Igniter & Battery

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There are two electrical requirements for the shay:

- An igniter to relight the oil burner.

- Headlamps on both ends and possibly cab lights to illuminate gauges. (The local folks run their locomotives after dark so working lamps are a necessity.)

The igniter and battery are discussed in this part and the lights will be covered in subsequent parts.

Unfortunately, no thought had been given to power generation or storage during the locomotive construction. There is no room for a small auto/motorcycle/lawn equipment type battery. The best alternative seems to be to stuff (hide) some D size cells between the tender frame members. That should be sufficient since there's no kids to leave the lights turned on. However, care must be taken to get maximum efficiency to extend battery life. To that end an electronically controlled 6 volt motorcycle coil was selected for the igniter and LED arrays for the lamps. Most the LEDs used in flashlights require ~3.9 volts each but can be arranged in parallel/series combinations of LEDs and resistors to form an array that will work at about any voltage greater than 3.9 volts. The motorcycle coil was the least expensive small coil I could find so that fixes the voltage at 6 volts or slightly less. Four regular 1.5 volt D cells gives 6 volts or four 1.2 volt NiCad or NiMH cells could be used to give 4.8 volts which would probably work or a fifth cell added to get 6 volts. I decided to start out with the four 1.5 volt cells and see how that worked out. If battery replacement becomes too expensive, I can switch to rechargeable batteries later.

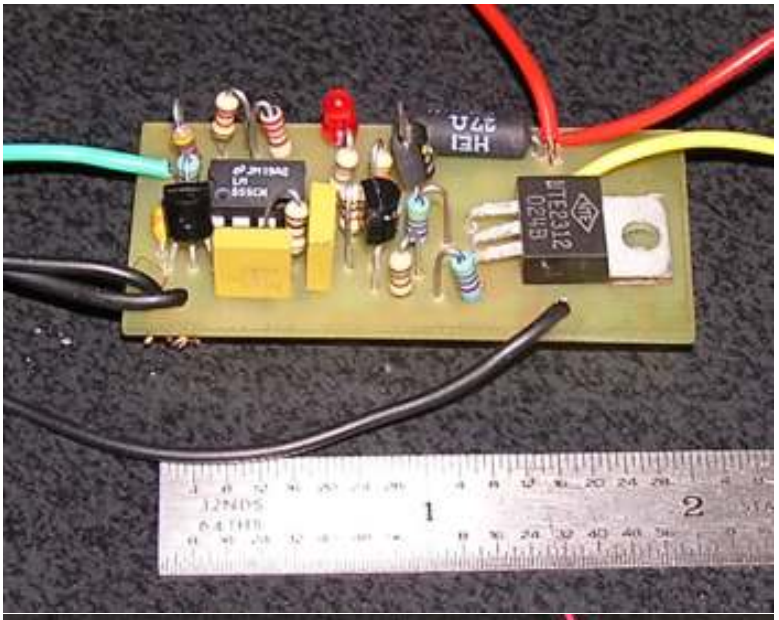
Igniter: The igniter was viewed as the highest priority electrical item so it was constructed first. (A large flashlight could be duct tapped to the front sill if needed before the headlamp is finished.) Dave Johnson provided much advice on the burner as well as the spark plug type and plug position as documented in the Burner Test & Modification Page . He also advised that most people use a Model T type coil that gives hundreds of sparks per second.

I'd heard references to Model T coils in a way that suggested that they were something special. Being an Electrical Engineer I attributed this to a myth or urban legend passed on by the uninformed. Dave said that Model T coils were available from Mac's Auto Parts. I checked out the coils at Mac's and found that four coils were used (one per cylinder) and the coils had contact points. Along the way I heard the term buzz coil applied to the Model T coil. At this point it sounded like they were indeed different; more than just a coil (my previous view was wrong --- not the first time). I then speculated the distributor distributed to the coil primary (6 volts) and that each coil was equipped with a vibrator (buzzer) to continuously pulse the coil whenever power was applied. A later conversation with my older brother confirmed the coils were self pulsing. (He also provided some tales about mischief with these coils in his youth.) The Model T coil sounded great but seemed to be larger than I wanted and I suspected that mechanical buzzer/pulser consumed significant power.

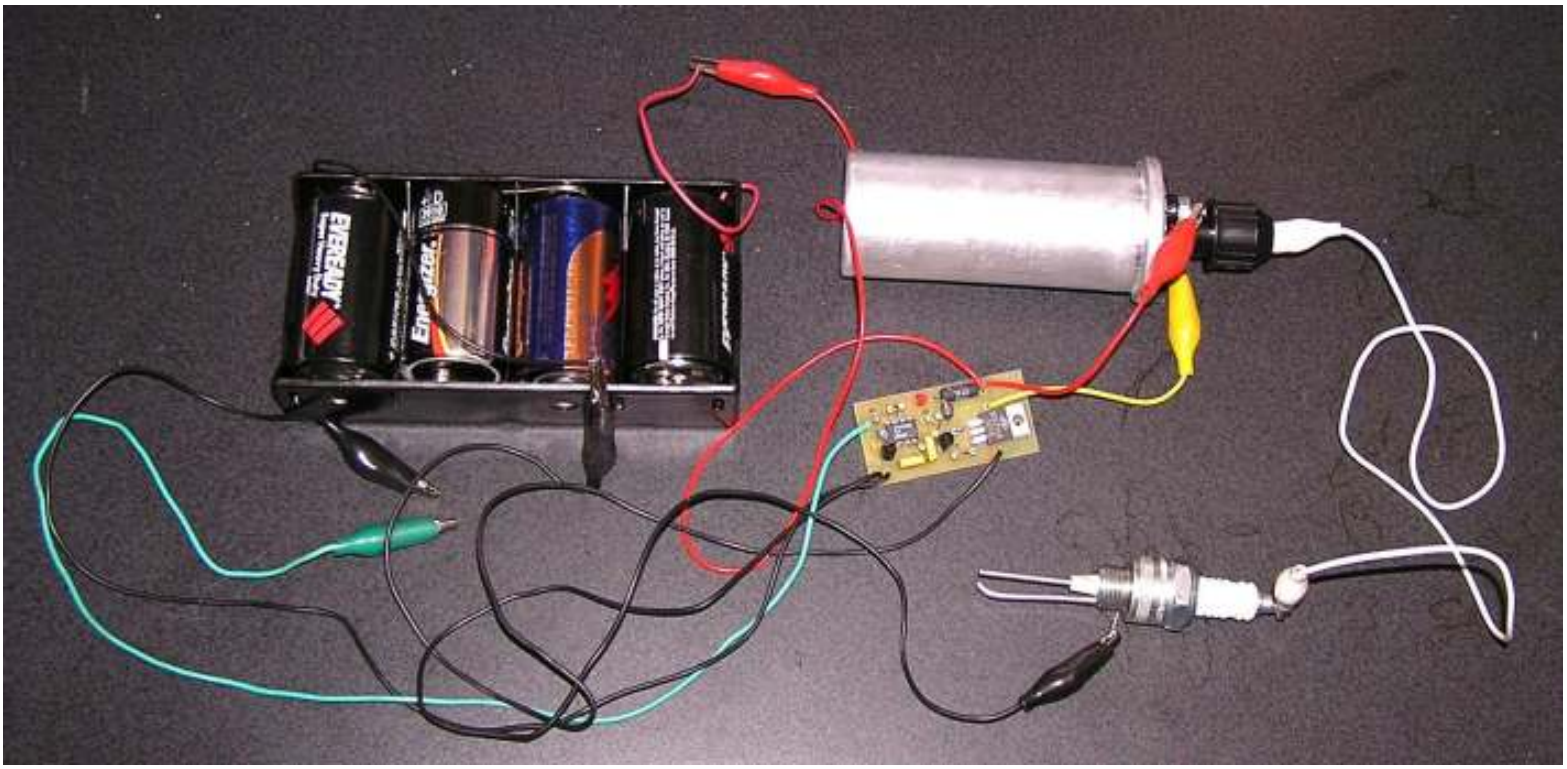
A subsequent Internet search found Jerry E Howell's website serving ignition needs of small model gasoline engines. Howell offers small coils and a kit to make an electronic circuit to pulse (buzz) one of his small coils or a 6 volt motorcycle coil. The buzzer kit and a few feet of small plug wire were purchased from Howell. A 6 volt motorcycle coil was purchased from the J C Whitney website. The size wasn't listed but it turned out to be smaller than a typical auto coil as hoped.

This is the J C Whitney 6 volt motorcycle coil. The total length to the tip is 5.5". The can diameter is 1.5" and the lip diameter is 1.875".

This is the pulser circuit from Jerry Howell. The kit includes all the parts shown except for the wire. It is easy to follow the instructions to assemble the circuit using a small (~ 35 watt) pencil soldering iron. For you electronic types, the circuit uses a 555 timer configured as a free running oscillator that drives a 3-transistor amplifier that in turn drives the coil. The output transistor has a very high breakdown voltage suitable for working with the coil. The circuit is turned on and off by a transistor switch in the 555 IC ground lead. The black wires in the photo are all connecting together on the circuit board and are connected to the negative battery terminal and the locomotive frame. The red leads connect the the positive terminal on the battery and to the coil (+) terminal. The yellow wire connects to the coil (-) terminal. The green wire is the control wire and is connected to ground to turn the circuit on.

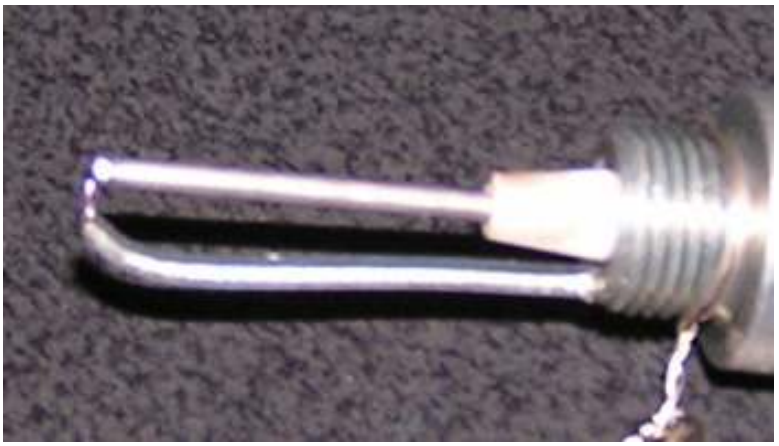


This battery pack was purchased from Radio Shack. It measures 5.5" X 2.875" X 1.4" high including the batteries that stick up from the pack. Radio Shack has another version of pack that has two parallel rows of two batteries on end. It is nearly the same size as this one. This one was chosen because it's easy to connect a wire to each of the cells. It's desirable to connect a wire between the third and fourth cells to pick off 4.5 volts to run the headlamps.



This shows the circuit hooked up on the desk for testing. The white wire is the high voltage lead from the coil. The alligator

clip on the end of the green wire is touched to the clip on the black wire to turn on the coil. It worked!



This shows the spark on the plug tip. The gap is about 0.1". A larger gap was tried but the plug arced closer to the porcelain where the gap was smaller. Another test was to dip the electrodes and porcelain in fuel oil and then see if it would spark. It sputtered a couple times and then started to spark again.

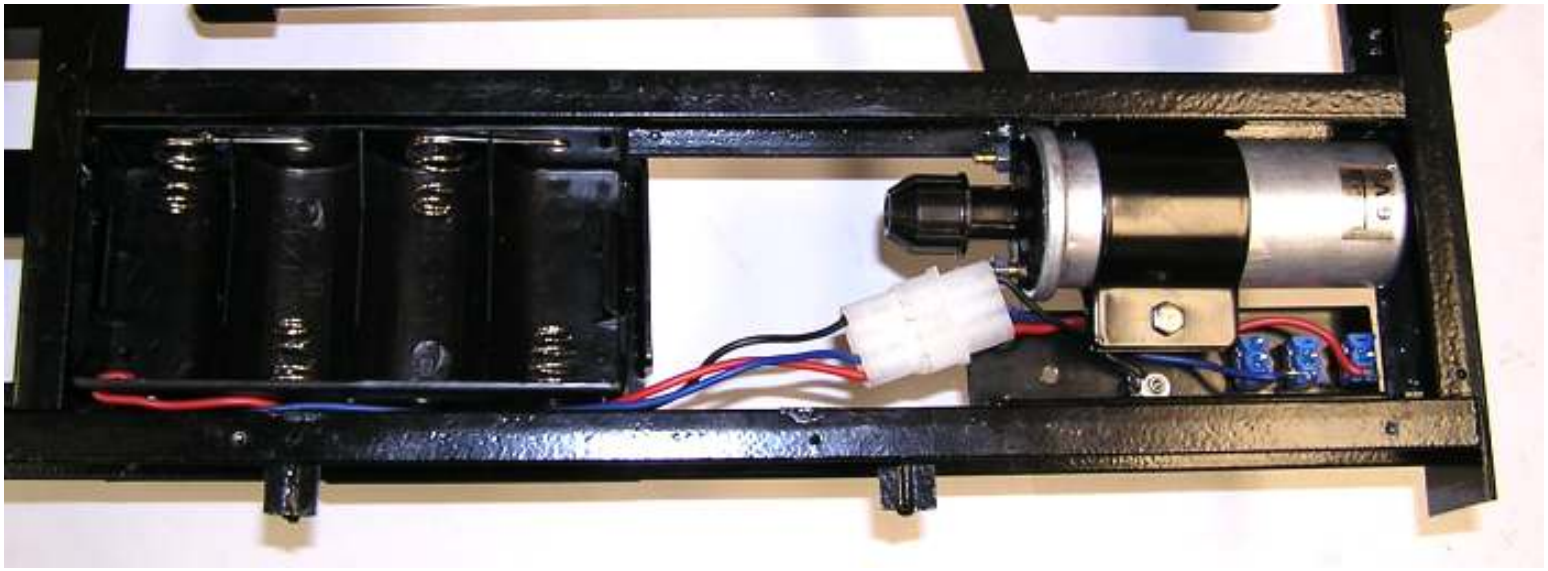
The current drain when sparking was measured to be a little less than 1/2 amp. The unit was tested at 4.5 volts supply and found to be erratic unless the gap was made smaller so 6 volt operation seems best. At this drain, the batteries should last all summer.

Wiring Everything Together: The most important goal is to get everything wired together and to have the result function properly. Another goal is to be able to remove all the parts without cutting or unsoldering any wires. A third goal is to have the wiring not look like a rat's nest.

Coil Mounting: The coil comes with the bracket shown. A spacer cut from 3/16" X 1/2" bar stock was silver soldered to the middle of the bracket. The bracket was attached to an inner frame channel with a couple 6-32 screws into the spacer. The bracket and spacer were powder coated before mounting. The photo is of the under side of the tender frame. The coil is located in the right front.

Battery Compartment: The battery compartment is between the coil and the bolster. The rear part of the compartment is merely a plate screwed into the frame. The front part is also a plate with a 90 degree bent at the front to form the front side of the compartment. The inside of the front plate slips under a bar and there is also a retaining lip on the rear plate to hold up the rear side of the front plate. Therefore, the front plate can be secured with one screw. Once this screw is removed, the front plate can be removed and the battery pack slid forward and down to be removed..

Switch Panel: A ~ 5" length of 1.25" X 1.25" X 1/8" angle was used as a panel for three toggle switches. The angle also served to anchor the wiring and hold the electronic circuit. The front (left) switch controls power to the igniter circuit. The middle switch will control the headlamp and any cab interior lights and the rear switch will control the rear headlamp. The panel is mounted with a couple 4-40 screws through the outside frame channel.



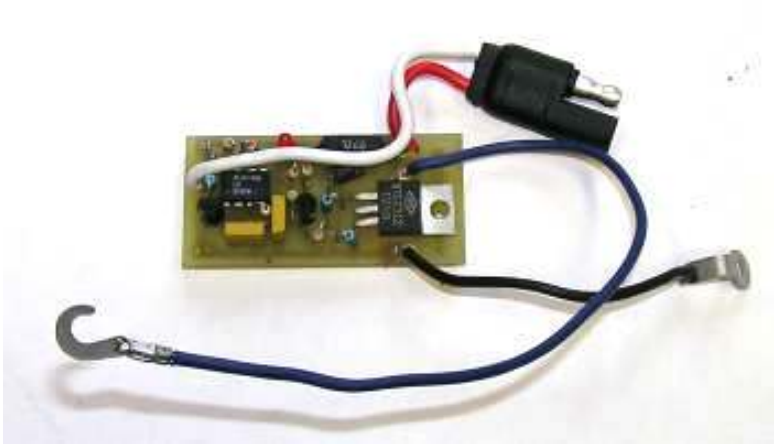
The above photo shows the top view of the circuitry. The tender front is to the right. This is all covered by the tender floor. The batter pack is connected to the switch panel via a 4 wire Molex type connector obtained from Radio Shack. Only three of the wire positions are used. The black wire is battery negative, the red wire is +6 volts and the blue wire is +4.5 volts (connected between the 3rd and 4th cell of the battery pack). On the switch panel side, the black wire is connected to a ground lug, the red wire to the front switch (igniter power) and the blue wire to the middle and rear switches (lamps).

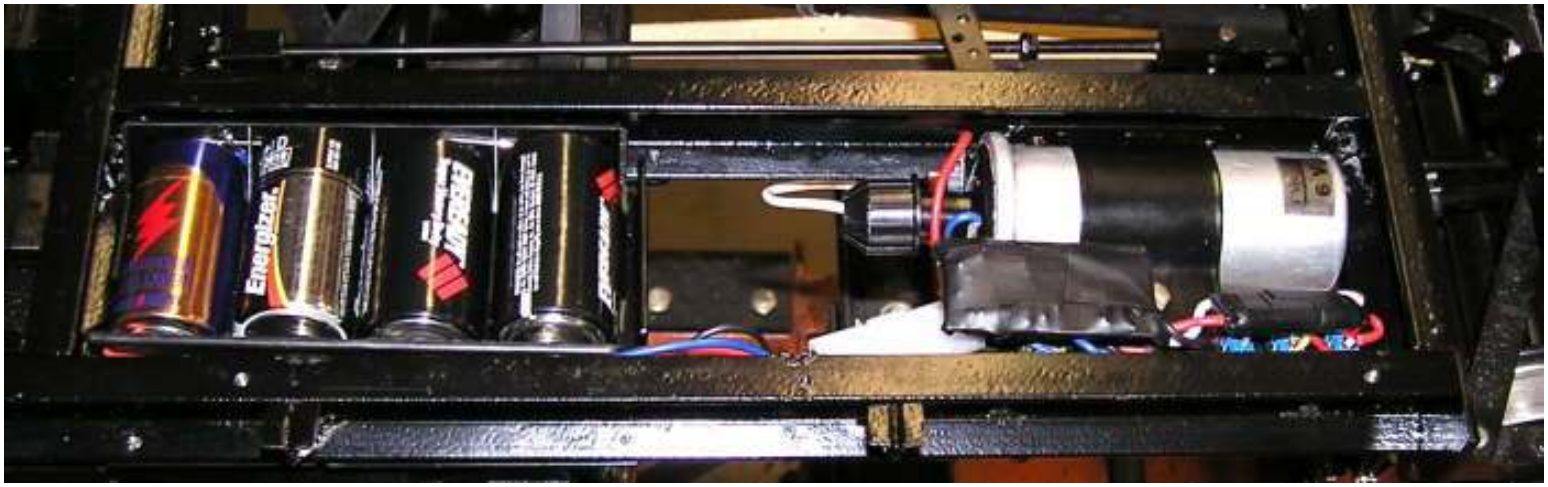
Molex Connector Pins: I thought I'd show one of the pins from a Molex connector. The loops on each side are trimmed off leaving a short stub slightly longer than the side of the pin barrel

(this is a female pin). The wire is fastened to the pin with a crimping tool. I also solder the wire to make sure it holds. The pins then slip in the plastic holder. the stubs keep the pin from going in too far and the barbs keep the pin from being pushed back out. The male pins look the same only have a slightly smaller OD and a pointed end. (You guys should be able to figure out the male/female part.)

This is the crimping tool I bought somewhere a long time ago. Radio Shack sells similar crimping tools.

Pulser Wiring: This photo shows how the pulser was connected to the other pieces. The blue wire with the hooked lug goes to the coil (-) terminal. The black wire with the lug is the negative terminal that goes on the same screw as the ground from the battery and a ground lead in the cable to the locomotive. The two wire plug is half of a 12" extension obtained from Auto Zone. This extension has mating plugs on each end and is intend to use to extend trailer wiring. The red wire is the +6 volt lead. The red wire on the mating plug goes the front toggle switch. The white wire is the control lead that is grounded to turn on the pulser. The white lead on the mating plug goes to the cable to the locomotive cab.



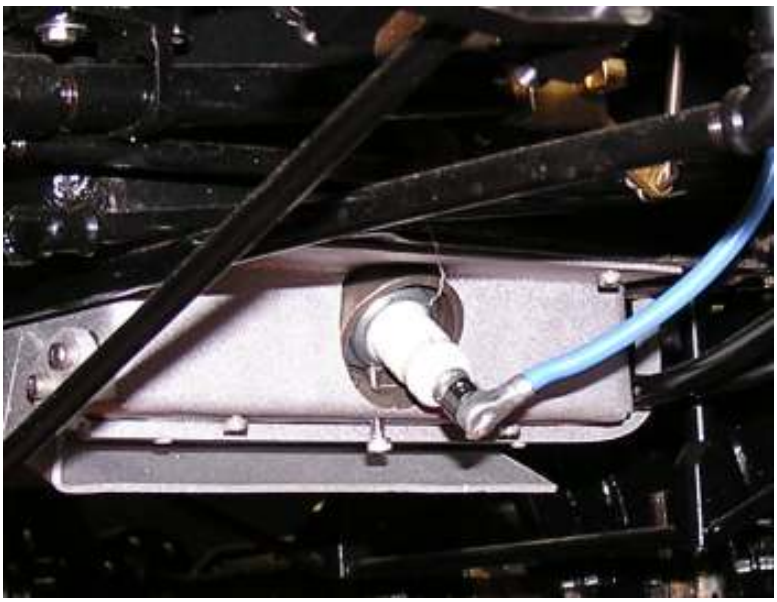


The above photo shows the pulser circuit covered with electrical tape and all wires connected. The red wire near the left end of the coil is the coil + 6 volt lead that has a hooked lug on the coil end with the other end connected to the front toggle switch. The two screws securing the switch panel are removed to drop the switch panel. The pulser circuit will drop down with the switch panel.

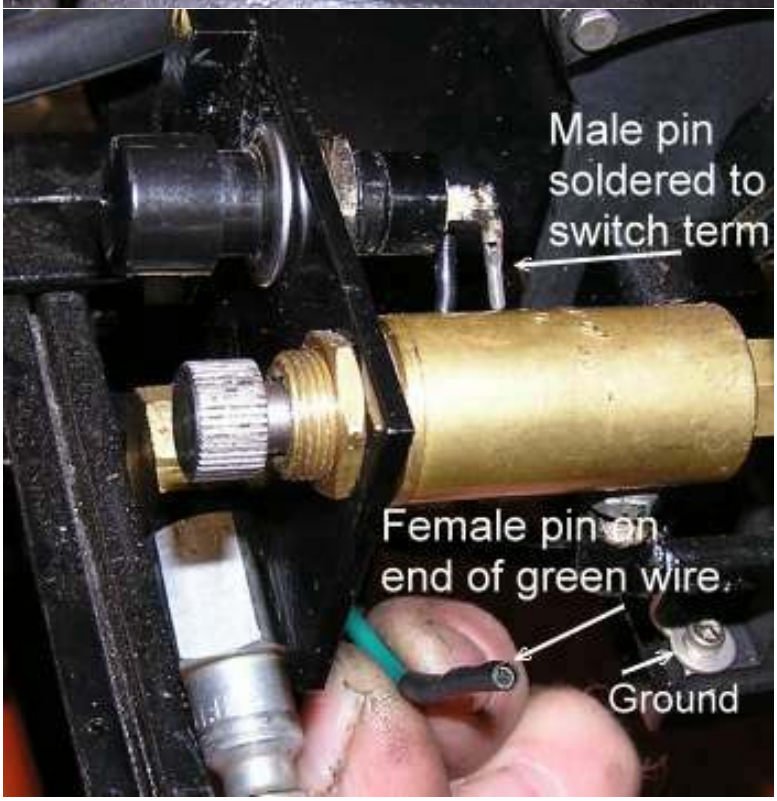
The wires between the tender and the locomotive are via a standard 4 wire trailer wiring assembly from Auto Zone. The cable had 12" wires on the tender end and 48" wires on the locomotive end. The white wire at the tender end connects to the coil high voltage terminal. The other three wires run through a rubber grommet on the switch panel and are secured by a cable clamp on the top side of the switch panel. The brown wire on the tender end connects to a lug on the grounding screw. The yellow wire connects to the middle switch for the locomotive lamps. The green wire is spliced to the the white wire that goes to the two prong plug to the pulser circuit --- this is the wire that turns on the pulser circuit.

Photo above shows the locomotive end of the cable with the cab floor removed. The white wire was cut off at the plug end and the stub spliced to the blue plug wire obtained from Jerry Howell with the pulser kit. That splice was covered with shrink tubing and a few layers of vinyl electrical tape. The four wires were then wrapped with the electrical tape to form a cable. The cable was taped to the right side water hose in several places. The cable was also taped to the copper tube from that right side hose under the cab floor. Note the the yellow wire was folded and taped to the water tube on the left side of the cab. This wire will be later connected to the headlamp and any cab lights. The brown wire is soldered to a ground lug that is screwed to the top of the truck bolster. The blue plug wire goes down to the spark plug. The green wire goes to the igniter switch beside the atomizer

Spark Plug Connector: The connector on the end of blue high voltage wire was taken from an old auto plug wire. The crimping part was shortened and then crimped over the wire insulation. A hole was drilled in the top to feed the wire through. I had intended to solder the wire connection but forgot. This is not critical as the high voltage will jump the short distance if there is a poor connection.

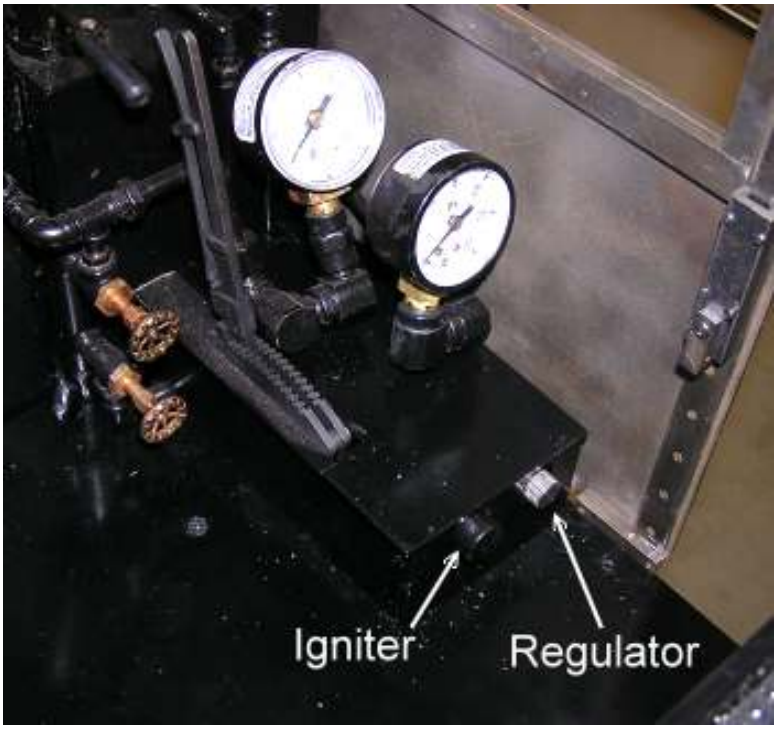


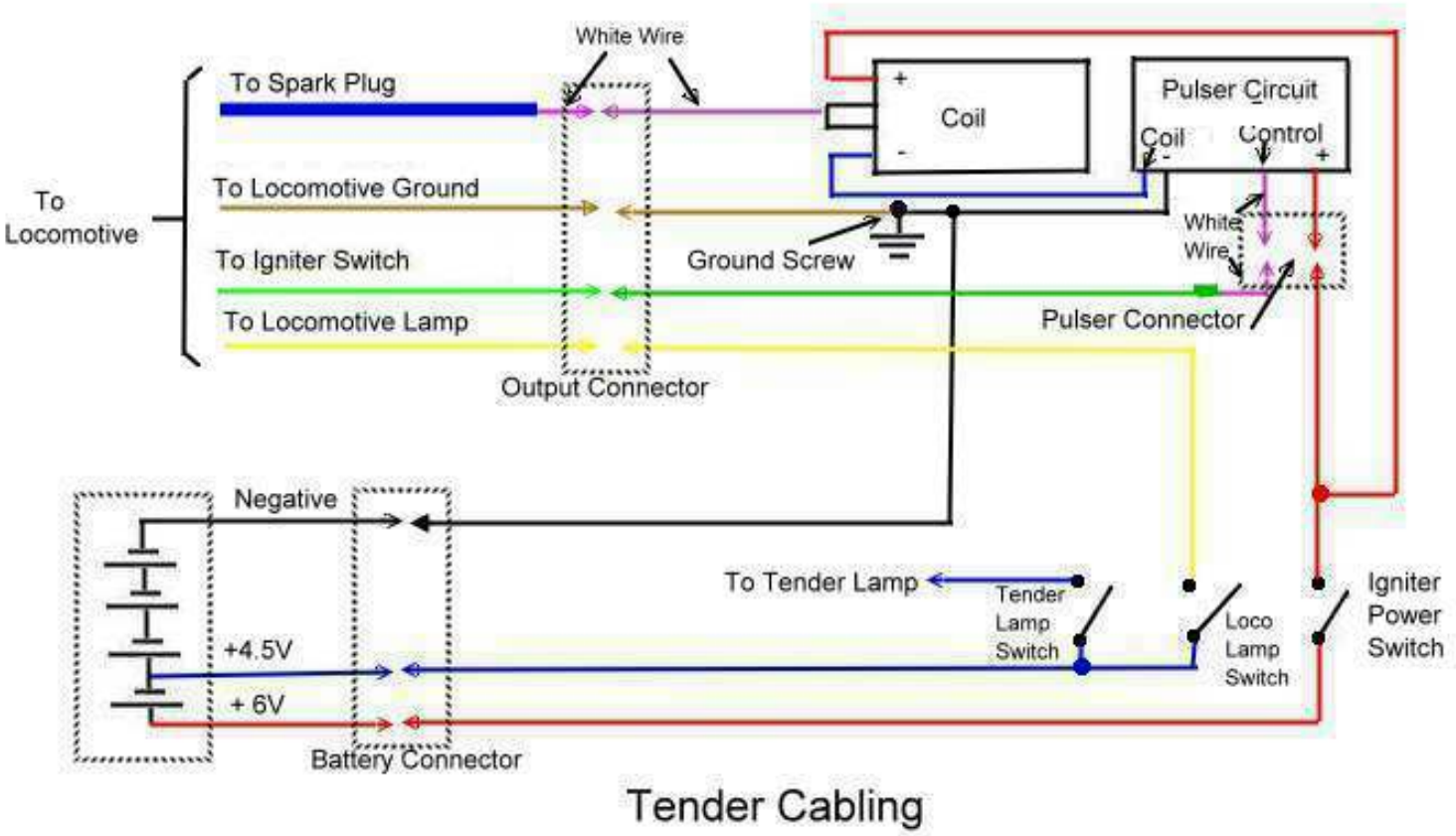
Igniter Switch: This photo shows the igniter pushbutton switch (Radio Shack) with the cover over the reversing linkage removed. One side of the switch is connected to ground via the black wire. The other end of the black wire has a lug that is grounded by one of the screws that secures the pilot block on the outside end of the reverse lever axel.



There is a one wire connector made of Molex connector pins on the green lead. The male pin was soldered to the switch terminal and the female crimped and soldered to the end of the green wire. The female pin was then covered with shrink tubing as shown in the photo.

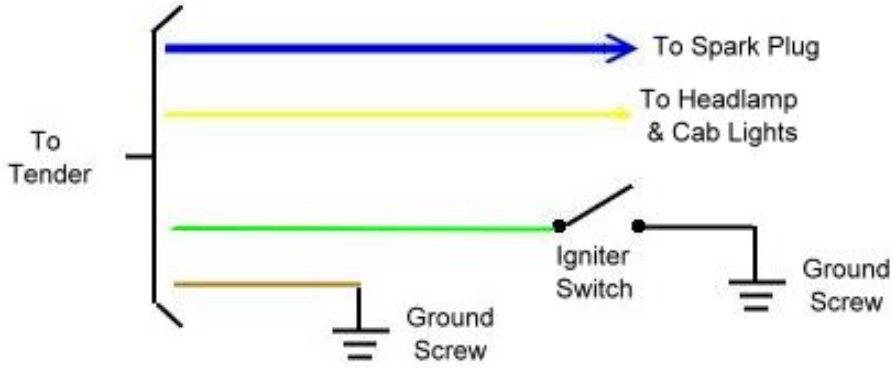
This photo shows the cab interior with the reversing gear linkage cover in place. The switch and regulator control are easy to access but sort of hidden since the prototype had neither control.





Tender Cabling

Cabling Sketches: The sketches above and on the right show the cabling used to connect everything together. Note that on the tender cabling the white wires are drawn as purple since the white wouldn't show on the white background.



Locomotive Cabling

Igniter Test: This part of the project has been done for a few weeks but I didn't want to put it on the website until the igniter was tested on a real live fire to make sure it actually worked. Today (4/15/04) was warm, sunny and beautiful in spite of the IRS so I sneaked off from lawn chores and fired up the Shay on the test stand. I couldn't get the burner to light initially with the igniter. That may have been because the fuel setting was incorrect. Once lit and adjusted properly I temporarily shut the atomizer valve --- flame went out --- then turned it back on --- then pressed the igniter switch ----- wow! ----it worked! After testing it a half dozen times I then played with burner adjustment. I found a bigger air hole is required at the rear of the pan --- the flame went out under full load unless the door was opened slightly. While fooling with this and other problems, the burner went out at least 25 times --- igniter relit it every time.

On a sadder note, the pretty blue high voltage wire near the spark plug is toast ---------- RIP. At times flames came out around the spark plug and went after that plug wire. The burner nozzle is horizontal and pointed right at the plug base. Maybe if I tilt it up a bit away from the plug hole, flames won't come out the plug hole (DAH).

Shay Project
NLW Home