S.O.S. - Save Our Switches
All About Relays for your Pantera

Several years ago fellow Houston Pantera owner, Jim Narum, had an electrical fire in his dashboard. He had a short with smoke somewhere in the dashboard and after he turned off the ignition switch the headlight Hi-Low switch burst into flames. He has yet to get his car back running. (Moral of that story is not to use petroleum based grease on your switches, spade connectors and contacts. I always use silicone grease, NAPA Sil-Glyde) Remembering this, and other similar stories, I have always been cautions when using the lights. Installing relays was near the top of my project list. Now, almost 2 years ago I started by studying Mike Drew's article on Hi-Low headlight relays "Volts of Confidence".

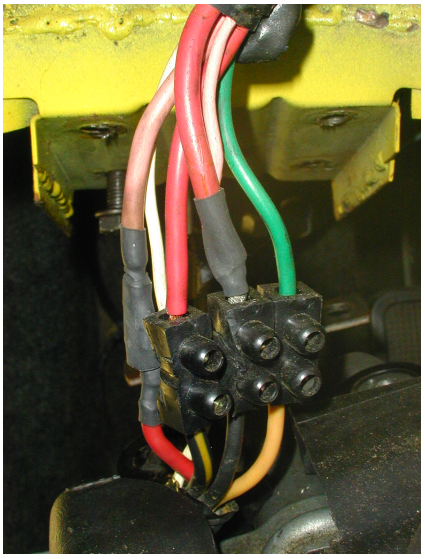
I should note that I discovered early in my wiring investigation the "Pantera - *Early* Pre-L Model" and "*Late* Pre-L" schematics on Mike Daily's "Pantera Place" website appear to be labeled backwards. In Mike Drew's write-up he states that the *later* cars had 2 pink wires going to the 2 radiator fan relays, and that sounds like a logical statement. That, most likely, was an improvement over the *early* wiring with a single pink wire used. The schematic labeled "*Early* Pre-L" has the 2 pink wires and most likely should be labeled as "*Late*".

I felt that additional dashboard switches might be susceptible to degeneration by high current in their circuits. This article explains my thought process and findings. You may choose to follow it, to modify these and/or other circuits, as you desire.

CIRCUIT DESIGN

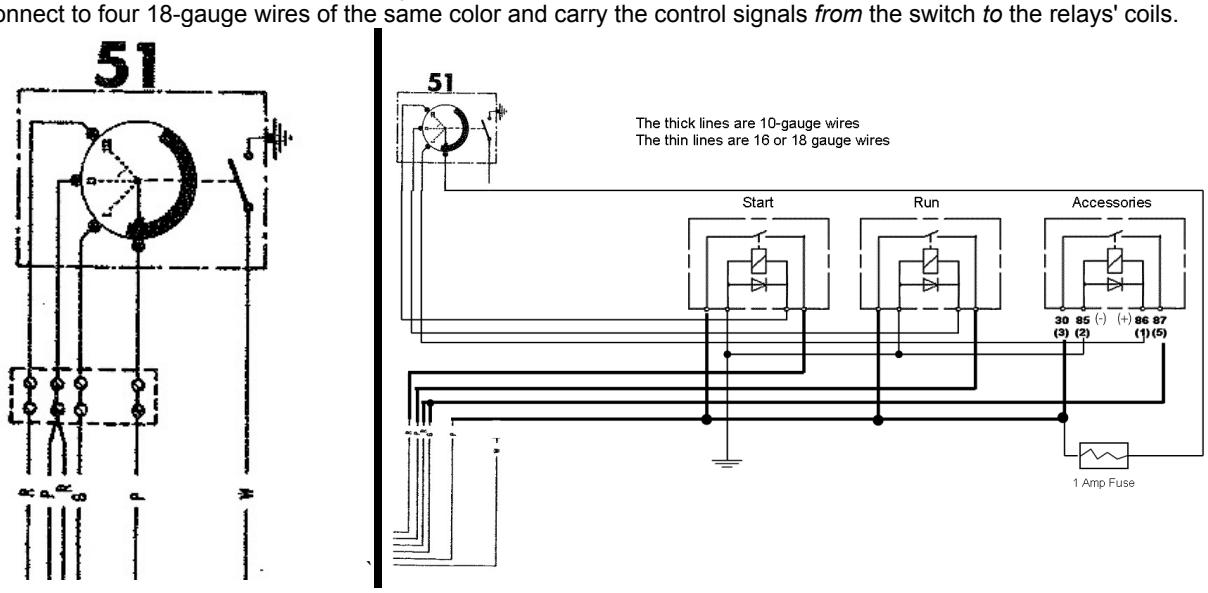
I started studying my Toyota MR-2's schematics for relay use and decided to install them not only on the lights, but the ignition switch as well. Later, on my list of projects, is to install relays on the AC blower switch. If we want to go over the top, you could also do the window switches.

Since I wanted to keep the "stock look", I did not want to install relays in the front trunk which is the method used in the Rick Moseley relay modification. So, the logical place to put these relays is near the ignition switch under the dashboard. From previous work on the ignition switch I knew that power into and the 3 line output from the switch all went through a 4 conductor terminal strip. It's the dotted box in the left diagram, #3, below. One side of the strip goes to the harness and the other side goes to the switch. This makes it an ideal point to wire in the relays.



1) Left photo - The black ignition switch terminal strip is shown on the left side of the photo, and the yellow 8-pin connector for the lights and turn switch is on the right.

2) Right Photo - Close-up of the terminal strip in ignition switch wires which will be removed. Top wires above the terminal strip are the four 10-gauge harness-wires to which 10-gauge wires of the same color will be attached. These new wires will send power *from* the relay's contacts *into* the car's harness. The 4 wires below the terminal strip will connect to four 18-gauge wires of the same color and carry the control signals *from* the switch *to* the relays' coils.

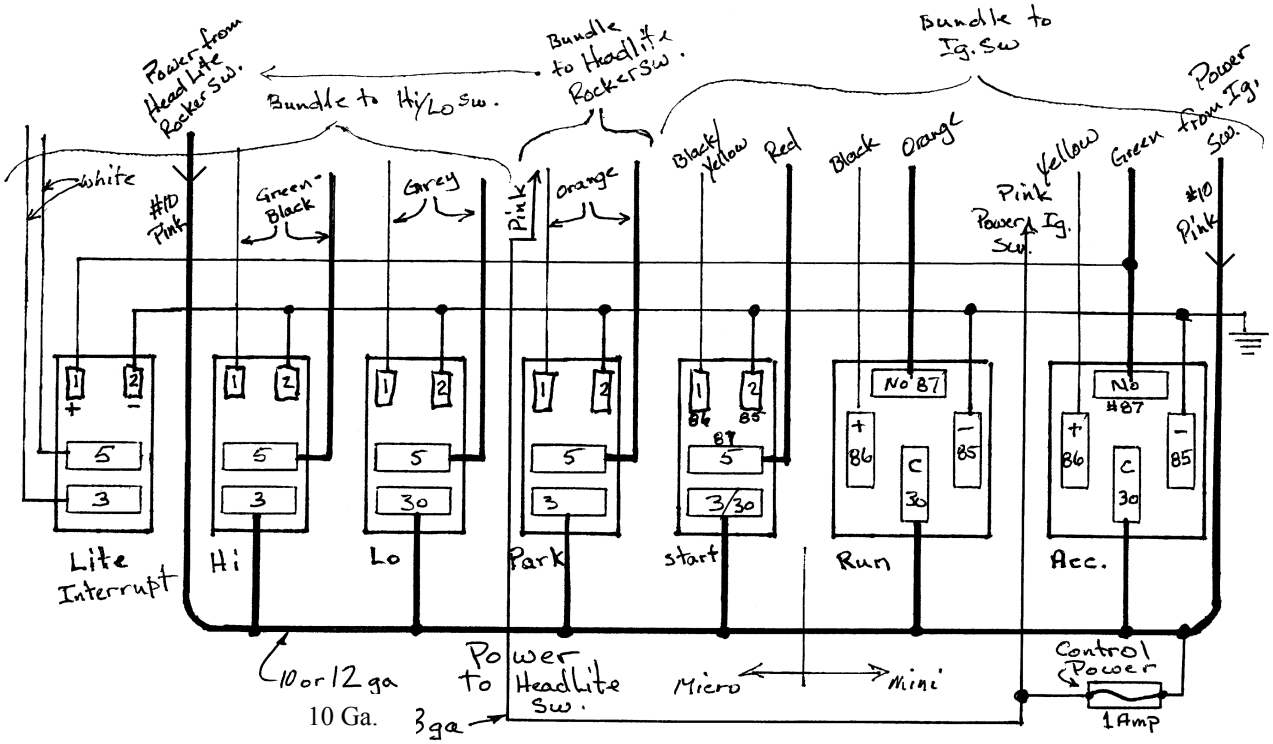


3) The ignition switch terminal strip is shown as the dashed box in the left diagram above.
4) It is replaced by the 1st arrangement of the ignition relay circuit, , shown to the right above.

Next, lets consider the headlight relays. After thinking about all the options and possibilities (for a few months) I wanted to put them in the high and low beam circuits, but why not the parking lights as well? That takes the *entire* load off the headlight rocker switch. The relays could be placed, as Mike Drew did, near the fuses. But, since every wire has 2 ends, I could also place them at the other end near the switch. Note – for the High and Low beams the switch output is on the steering column and the parking light output is at the headlight switch itself. That's close to the ignition switch as well. So, its looking like *all* 3 light relays could be located near or with the ignition switch relays!

5) I used a precision wire stripper to be able to accurately measure wire gauge on the Pantera harness.

From the ammeter we have the well-known BBW, 8-gauge Big Black Wire, with 2 big pink wires on one end going to the ignition switch (10-gauge) and the headlight switch (12-gauge). This means that 2 pink main power circuit wires go to the relay block, one to the headlight end and the second to the ignition switch end. Rather than using two separate wires, I just used one long 10-gauge wire from the ignition power wire, feeding all 6 relays, and continuing to the headlight power wire. This way both ignition and light power wires feed all 6 relays, sharing the load. If desired, you could use 2 separate wires.



6) Above is a diagram of the wired relay module - as viewed from below, or the terminal side of the bases

Battery power is *always* supplied to the ignition and the headlight switches. This is what Mike Drew noted in his article. With the ignition OFF, you can turn ON the headlights and, with them still retracted, you can burn the paint around the lights. The raise/lower motor is powered from the ignition switch's Accessory power terminal. The fix for this is to route control power (the White wire in diagrams #6 and #16) for the Hi - Low switch through a separate relay, the Light Interrupt relay, which is turned ON when the Accessory circuit is powered ON. The Accessory circuit is ON when the key is in the Accessory and the Run positions , only. The side benefit of this approach is that Accessory power is also off when the ignition switch is in the Start position. Therefore, the head lights will turn OFF when you're starting the engine, a nice additional feature to ensure more power is available to the starter. Finally, I have the last change to the circuit.

HARDWARE

While studying the circuitry, I was also looking at possible relay hardware. This portion of the project had the largest learning curve.

RELAY BASES

While cruising the Internet, I found that Hella manufacturers two relay junction blocks or bases. One holds 4 mini-relays and the other holds 7 micro-relays. Both relays are an ISO standard configuration, so different manufacturer's relays fit the bases. I bought both from Amazon for about $35 each to evaluate them.

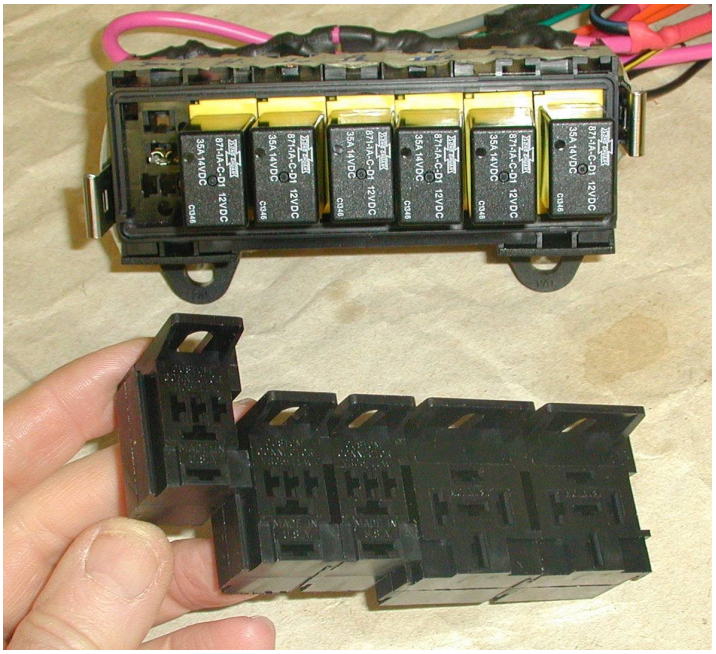
7) The Hella 7-position **micro** relay base (top) was not sturdy. The Hella 4-position **mini** relay base (bottom) seemed sturdier but not used. Note the blue Hella relay with integral fuse holder, which I felt was not desired in this application.

The **mini** 4 relay block would work for the ignition switch – ACCESSORIES, RUN and START – with 1 unused slot. I could then use another mini 4-block to control power to the lights – PARKING, HIGH, and LOW. Or, better yet, I could use the 7-**micro** relay block to hold all of the relays on a block the same size as the 4-relay mini block. After looking under the dash for while (I used a lot of Tums in this project), this small block would easily fit just to the left of the steering column. This is close and convenient to the ignition switch and the high - low headlight switch, which are on the steering column. The parking light relay required an additional one foot length of wires to connect it to the headlamp rocker switch.

The difference between mini and micro relays is their size and current capacity. *Mini* relays are a cube approx 1" on each side. These were the type used in Mike Drew's write-up. *Micro* relays are ½ the volume, that is shown in the photo of the 2 on their respective blocks The other difference is the current capacity. The *mini* relays are rated from 20 up to 50 and 70 amps. *Micro* relays are rated up to 30 to 35 amps. I am not too worried about the current capacity after looking at Bosch performance specs. They rate these relays for a hundred thousand cycles under full rated current or 300,000 cycles at 75% load, so even if I full load one, I will never live long enough to wear one out. So, I decided to use the Hella 7-mini relay block.

I will detail the assembly of this block later, because after constructing it I found that the spade connectors were not firmly held in place and the 7-position assembly was not robust. Yellow plastic inserts hold the female spade connectors in place, which they did not secure adequately. Some of the female terminals pushed out when the relays were installed (that's why relay specs talk about insertion forces!). So I took it apart and looked for an alternate. That's when I found the outfit Waytech.com which sells a vast selection of electrical supplies for auto manufactures and modifiers plus marine applications. When looking at the drawings online, I found the "panel mount" type relay base is manufactured by Bosch, or is at least a Bosch design. Also apparent when looking at the drawings on line was that the

tang and slot on the side of each base would connect 2 or more mini *and* micro bases together to make your own multi relay base containing both sizes.

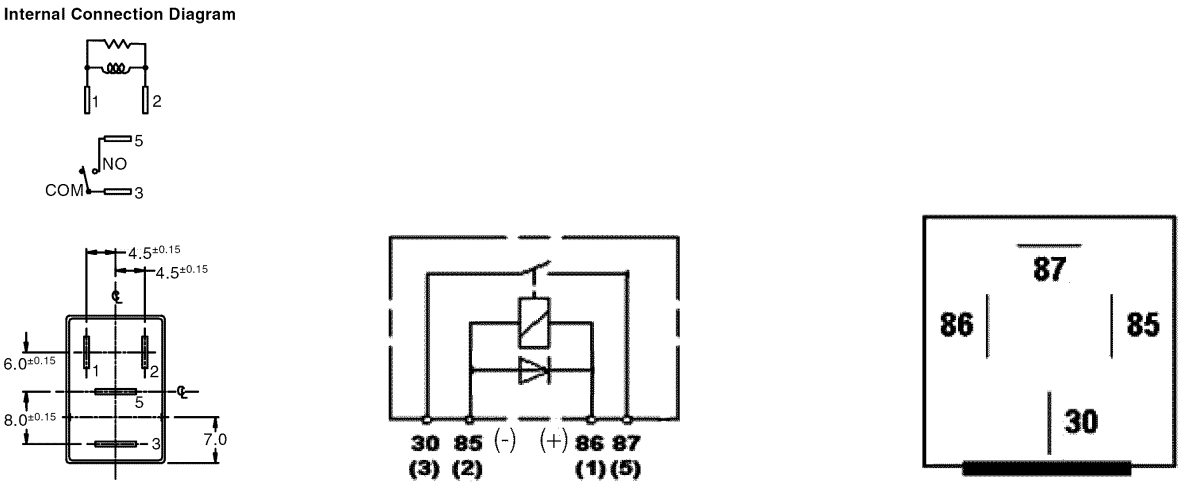


8) Panel mount Bosch type relay bases with tang and slot on the side of each base can connect 2 or more mini and micro bases together to make you own rugged multi-relay base containing both relay sizes. The Hella unit is at top of photo.

OK, we are finally progressing. When I built-up the Bosch type base, I used 2 mini bases (since I now had the option) – for high capacity 50-amp, ACCESSORY and RUN – then I added 4 micro bases – for lower capacity 35-amp, START, PARKING, LOW beam, HIGH beam, and Light Interrupt. Yes, you are correct, I have a relay at the ignition switch powering the start circuit which consists of a relay (the solenoid) which energizes the starter. You could argue that it is not necessary. Possibly a bit of over kill, but, I paid my money and I made my choice, just as I use a relay to control the parking lights.

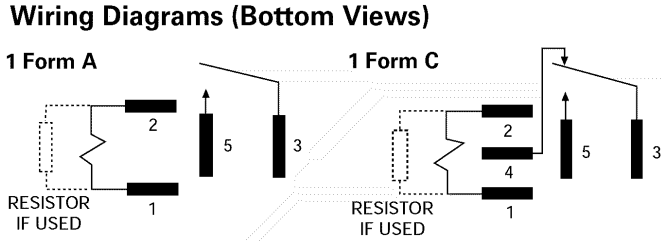
RELAY SELECTION

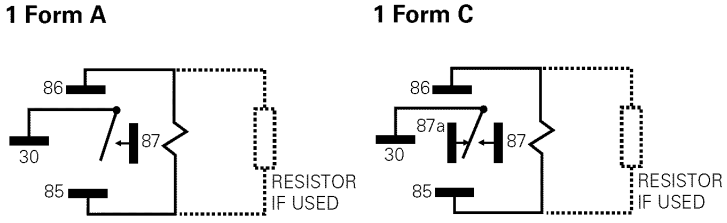
A few words about relay selection. I am calling the low power circuit, which operates the relay's coils, the control circuit. The power circuit is the portion of the relay containing the high current contacts. Relays have 1) simple coils, or 2) diodes across the coil, or 3) resistors across the coil. When the control circuit breaks, there is a back EMF generated by the relay's coil. This makes a spark, admittedly small, at the switch we are trying to save. This is similar to your ignition points getting burned by the coil. Per Bosch engineering data sheets, a resistor limits this voltage to around 100 volts and a diode limits this down to about zero. On another high current relay data sheet I found the statement that a suppression *resistor* slows down the contact release time causing more erosion of the relay's contacts. Again, the relay will last longer than I, and I would rather replace the relay than the switch. When looking at specs I always try to get a relay with a *diode* across the coil to limit any sparking at the contacts I'm trying to save. ***Note*** - this requires that you wire the base with the correct polarity on the control (coil) terminals. This *should* be observed even if you are not installing diode relays. At a later date the only spare you can find may be fitted with a diode. When doing this project, I collected several relays from derelict cars I ran across. Some had resistor and some had diodes and some were not marked.



9) On the left is an ISO **micro**-relay with a resistor across the coil, and on the right is a **mini**-relay with diode across the coils. Both views are looking at the bottom of the relay. Both relays use the same 2 conventions to label the terminals, either 1 through 5 nomenclature or the 30, 85,86, and 87 nomenclature . Other types of relays are available, such as, ISO 280 micro and ISO 280 ultra micro. They do not seem to be as widely available at this time so I did not use them.

Some relays are single contact, called type-A or SPST, and some are change over, called type-C or SPDT. Changeover have normally closed, NC, contacts *in addition to* the normally open, NO, contacts, hence the name Single Pole *Double* Throw. The pin arrangements are identical except the type-A are missing the extra pin-out, hence the name Single Pole *Single* Throw. I chose to use type A relays. As a replacement, a type-C could be used with the extra contact (the #4 or #87a as shown below) protected by the base but not connected to a terminal.

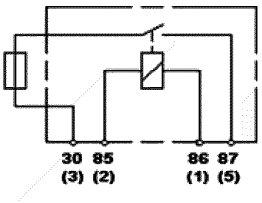


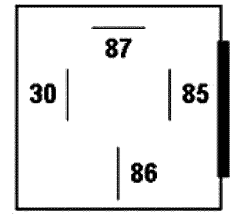


10) ISO (similar to SAE, but electrical) **micro**-relay, top, and **mini**-relay, bottom, terminals are an industry standard configuration.

I bought all **micro** relays for the first design and chose the highest capacity, 35 amp, I could find, since they would also be use on the Run and Accessory circuits. They are Song Chuan #871-1A-C-D1, or Waytek #75722 ($2.58 each). If you want Bosch (now called Tyco) 30 amp SPST **micro** relays, they are Tyco #V2337-A1601-X003, or Waytek #75530. After redesigning the relay module with Bosch type bases, I used two 50 amp rated Bosch/Tyco **mini** SPST relays on the Run and Accessory circuits. They are Tyco #V23234-B0001-X001, or Waytek #75301 ($7.04 each). The light circuits remain the Song Chuan micro relays. I am providing the manufacturer's part number so you can compare prices from other vendors. Prices vary wildly. If you put a Toyota label on the same relay you could buy it for up to $40 each.

Beware – some mini relays by Hella have a fuse installed on the high current contact side of the relay, terminal #30. This type of relay is not commonly used. If you use it be sure to buy spares because the spade connectors are not in the same positions as the ISO standard mini relay. A common ISO relay will not operate properly if put into a base set-up to use Hella fused relays.





11) The unique Hella fused relay's pin arrangement is not a standard and could cause problems when used with a base, as I am doing.

SPEAKING OF FUSES.
Fuses are designed to burn up and interrupt the circuit in the event of a short to ground. This *should* happen before the wires and insulation in the circuit burn up. Finding appropriate fuse rating for automotive wire sizes is not as easy as it is for house wiring. I finally found a chart in the Waytech catalog which gives us some guidance.

From Wayteck Inc. Catalog, pg 100, 2014

Gauge	Max. Continuous Amps at 77F (25C)	Max. Continuous Amps at 122F (50C)
4	121	80
6	91	60.5
8	68	45
10	51	34
12	34	22.6
14	30	19.6
16	20	13.3
18	16	10.6
20	12	8
22		*I use these lower ratings*

The wiring I've added is all under the dash and, I believe, well protected from damage and associated short circuits. From my relays, power travels 3 feet in the original wiring harness over to the fuse box. For this reason I did not add any fuses to the power circuits. I *did add* a fuse holder in the control circuit supply coming off the pink 10-gauge power buss. The low current from this fuse is what travels through the headlight and ignition switches and operates the relays' coils (see diagram #6). If I should go poking around trouble shooting a switch, there is a distinct possibility of my clumsy fingers shorting out something at the switch. To prevent a short damaging the switch, the 1 amp fuse was installed. Each relay's coil pulls about 0.15 amps. (12volts/85 ohms), so RUN, ACCESSORY, Headlamp up/down relay, PARK, plus the HI *or* LOW beam relays concurrently pull about 0.75 amp.

WIRE SELECTION
My first thoughts about selecting wire were 1) use wire the same color as the wire to which it attaches, and 2) use wire with the same gauge to which it attaches. *All* new relay wires were the same color as the car's harness or switch wire to

which they attach. Color matching is mandatory for troubleshooting in the future, *but* the problem is using the same gauge wire. The **low power control circuits** between switches and relay coils do not need to be more than 18 gauge (note the large current rating of this small wire in the table!). Matching the larger wires going to the switches is unnecessary and would make a large stiff cable bundle that really occupies a lot of space. Keep it small so it's easier to work with. Wires attaching the relay's output to the **power circuits** were the same gauge as the harness wire to which they attach.

I noted that the 10-gauge wires I used didn't bend as easily as the original harness 10ga. wires. Worst offender, the 10-gauge power wires at the ignition switch, were almost as bad as bending coat hanger wire. The 10 gauge wire purchased from both Rhode Island Wiring and WiringProducts.com both contained 19 strands of 23 gauge copper, where as, the original harness wires contained about 30 strands of a smaller gauge. If you can find it, try using a 10-gauge wire with more strands for flexibility. The smaller gauge wires (12 and 18) are not problematic.

BUYING THE PARTS

Relays and Bases
Forgetting about the Hella relay bases, I used 2 of Waytek's (waytekwire.com) *Mini* 5-Pin Panel Mount Relay Connector their P/N 75280(mfg by Bosch, or at least a Bosch type design), and 5 of the *Micro* 5-Pin Panel Mount Relay Connector (mfg by Bosch) their P/N 75290. They are cheap - the minimum order is 10 pieces each size for a total of $6.79 for 10 bases. I found that Waytek had good prices, good selection, and the most informative specifications available online. Now I have the material to later install relays on the AC blower motor switch. All spade terminals on *mini* relays are ¼" and Waytek have these terminals for 16-14 gauge control wire (Waytek #31073) and for 12-10 gauge power wire (Waytek #32074). Power spade terminals on the *micro* relays are also ¼" but the control terminal are 3/16" spade terminals for 20-16 gauge wire (Waytek #30075). I also bought all the relays from Waytek. The part numbers were detailed previously in the section on design.

Wire
I checked several places and Rhode Island Wiring had good prices, *very* large selection of wire colors, and only a 10 foot minimum length order. So I ordered all the wire from them. Remember, it's a very short run from the left side of the steering column to the ignition and Hi-Low switches and only about 1 foot longer for the parking light wires to the headlight switch. If you are doing additional wiring projects go ahead and order wire for that work, as well, to reduce postage costs. My car had no radiator fan relays and a lot of fan wires cut out. I made a table of the various gauge wires, their colors, and their lengths which I would require to return the radiator fans to stock wiring, headlight switch, and the ignition switch projects to make one order. Rhode Island did not have 10-gauge pink wire so I purchased this wire from WiringProducts.com

Connectors
While ordering parts let's replace the 4-wire *terminal block* between the ignition switch and the wiring harness with a 4-*wire connector*. On a website called PerformanceConnectorSystems.com I saw a connector very similar to the big yellow connector (see photo #1) DeTomaso used for all 8 of the headlight and wiper wires. It was called a Packard Type 56 connector on this website. It's an old standard connector design since 1956. In this application it's useful since it is not sealed so you don't have to buy different size seals to fit each size wire, etc. Under the dash I don't need a sealed connector, the yellow one is not, and its been working OK for the last 40 years. Rhode Island Wiring has them listed as GM connectors. Waytek has the same style listed as Delphi-Packard 56 connectors. I got a 4 cavity connector from Rhode Island Wiring along with male and female terminals. Waytek is cheaper per part but you must buy some of the connectors and terminals with a 10 or 50 piece minimum. If you plan on doing more wiring Waytek is the better way to go. Like I said earlier, this was all a learning process, hopefully you can learn from my false starts. I was not sure of the lone white wire's routing. Therefore, I did not put it into the 4-pin connector for potential easier repair ability later on. *Note* - After purchasing the Packard connector and comparing it's female terminals with the Bosch type relay female terminals, guess what, they are identical! I later found on one Bosch data sheet where they refer to "Packard terminals" used with their relay bases. Male spade terminals are used in connectors but relay bases do not use male terminals, they are part of the relay's base.

BUILDING THE RELAY MODULE

Now to the nuts and bolts of building the relay module. The high level strategy was to build, on the workbench, the relay base with all wires attached at approximate lengths. Power the module with battery power from jumper cables,

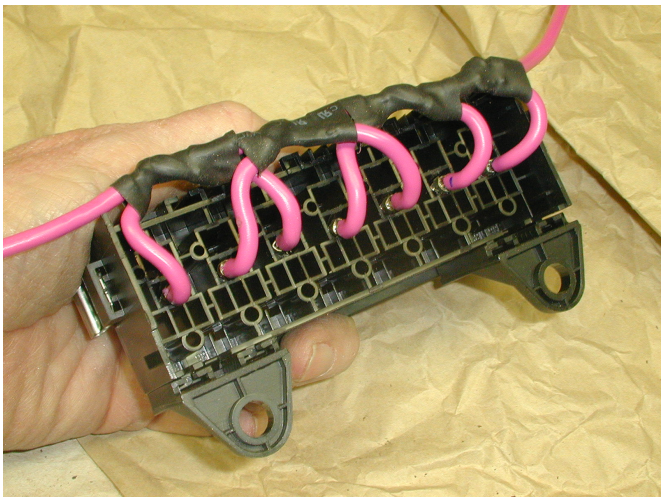
put a tail light bulb (my old #1156 test light with alligator clips) load on each relay, and fire the relay with test leads to the battery. Luckily, the light illuminated with each relay and no smoke was produced (obviously, I didn't use Lucas relays). The 3rd step was to place the relay block into position, run wire bundles, cut the wires to length, cut the harness wires (gulp), and solder them to the relay wires. The 4th step (the smoke test) was to turn on the battery (or reconnect, if you don't have a disconnect switch) try the ignition and light switches. If there's no smoke put in the 1-amp fuse and again try the ignition and headlight switches. Check for proper operation, there should be no smoke if you did things correctly! Finally, I wrapped the wires with friction tape to protect the 2 bundles - 1st bundle - ignition switch wires plus Hi-Lo wires and 2nd bundle - the parking light wires. *As a note* - I left slack in the wires so that I could lower the steering column for repair work, or pull the switch/gauge console panel out to gain access to the back, or drop the relay module to change relays.

WIRING THE RELAY BASE

Wiring the bases is the hardest part of the job (but much easier with the Bosch type base). I started with the 10-gauge power feed to each relay. I used a long length of wire with 1 end shorter. The short end going to the ignition switch's pink power wire and the longer end (about 24") going to the light switch's pink power wire. The length in between was the length of the relay block, and forms the U-shaped relay power buss shown in diagram #6. With my high quality wire strippers I cut into but not stripped, the insulation where a connection needs to branch off the power buss to each of 2 relays. I cut into the insulation 2 places about ½" apart and sliced along the insulation between the cuts, forming a ½" long window of bare wire. I did the same window in a piece of 10-gauge wire *about* 5"-6" long (I should have documented the lengths). I then made a half twist of the short jumper wire over the long buss wire and soldered the two windows together.

12) The pink 10-gauge power buss supplying current to all (except the light interrupt relay) is shown being soldered to a jumper pair.

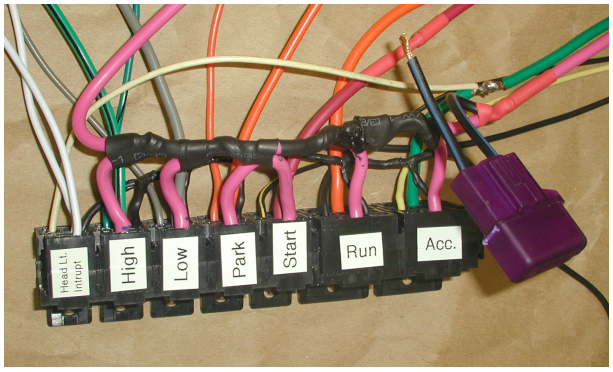
This requires a large soldering iron. Mine is an old Radio Shack 45 Watt iron with a fairly large (3/16") tip. barely big enough. If yours is smaller you might need 2 irons to supply enough heat since 2 ten gauge wires crossing soak up a lot of heat. Each solder joint will then have two 10-gauge jumper wires to feed power to 2 relays. I insulated the exposed solder joint with 3/8" heat shrink tubing (I love soldering connections and covering them with heat shrink, as shown in the photo, above). With this type connection and the heat shrink you can't connect two closely spaced relays (see the jumper wires crossing in the photo?). Let's say we are connecting jumper wires for relay #1 and #3 in your block. Move down a distance and repeat by cutting a window into the power buss and soldering in another jumper to 2 more relays, #2 and #4. Install the heat shrink after each jumper connection because the next one will block access to the first.



13) You can see it is difficult to bend the 10-gauge wire. I had to get creative and alternate the wires, connecting the 1st soldered jumper to relays #1 and #3. This photo is of the Hella relay block which was ultimately not used, but the 10-gauge buss was resoldered with new terminals and reused.

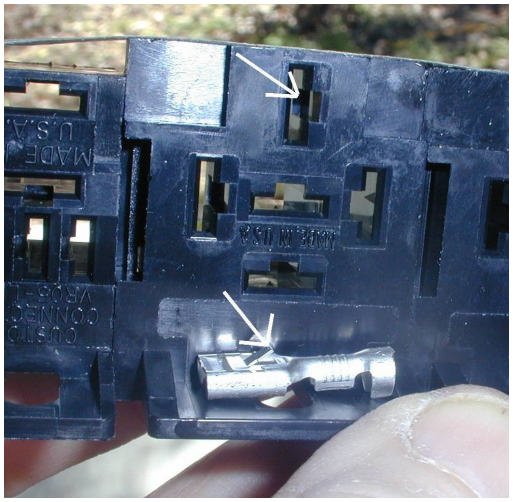
Be prepared to do this 2 times if you get things out of alignment. Your second attempt will probably look better than the first. Remember, when soldering these big wires, the solder has to flow well into the strands of wire, or you are not supplying enough heat. Ask a neighbor to come over with his soldering iron and he can help hold wires while soldering with his other hand. Like I said, this is the hardest part. Make sure your 10-gauge jumper from the 10-gauge buss is positioned properly and able to bend into position to fit into the relay's "common" power terminal, which, on a *mini* relay is terminal #30 and on a *micro* relay is terminal #3.

I next prepared in a similar manner a ground buss from an 18 gauge black wire. It connects the ground-side of each coil (on a mini relay it's a ¼" terminal #85, and on a micro relay it's 3/16" terminal called #2 or #85) to a ground point near the steering column. I made sure to connect the correct side (the - side) of each coil since I was using some coils with diodes for arc suppression. This completes the power and ground busses which are common to all the relays.



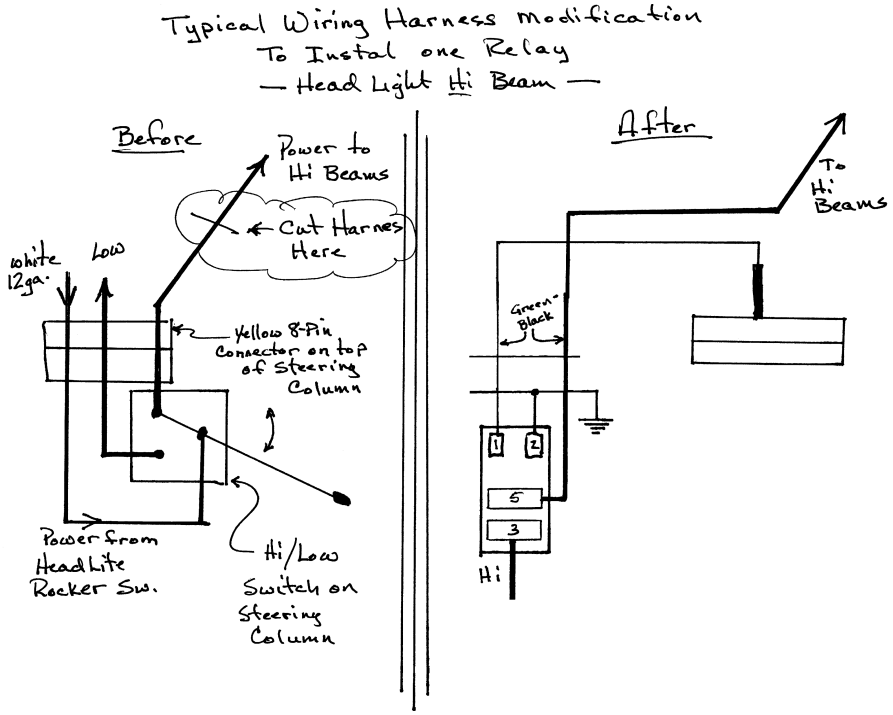
14) Close-up of the finished relay module with Bosch type bases and 10-gauge pink power buss installed along with the other wires and the fuse. Note the permanent labels for each relay base, the relays have not yet been installed.

I soldered a ¼" relay terminal to the end of the large 10 gauge power-out wire (of the correct color) and stabbed it into #87 terminal on the assigned relay base. It must be long enough to go to the point of the harness-end of the car's cut harness wire. With the same color #18 ga. wire I connected a terminal (either ¼" or 3/16") to its end, stabbed it into terminal #86 of the relay base to power the coil. Diagram #16, below, shows this for the Hi-beams and both wires are Green with Black stripe. The harness wire which was cut was Green with Black stripe.



15) When the terminal is stabbed into the back side of the relay, it's barb, lower arrow, snaps into a recess, upper arrow, holding it firmly in place. Same with the Packard 4-pin connector female terminals. The connector's 4-pin male terminals are different. This is a better arrangement than the Hella micro bases.

I cut the 18 gauge wire the length to run to the same point where the harness wire will be cut, only this time it will be connected to the switch-end of the cut harness wire.

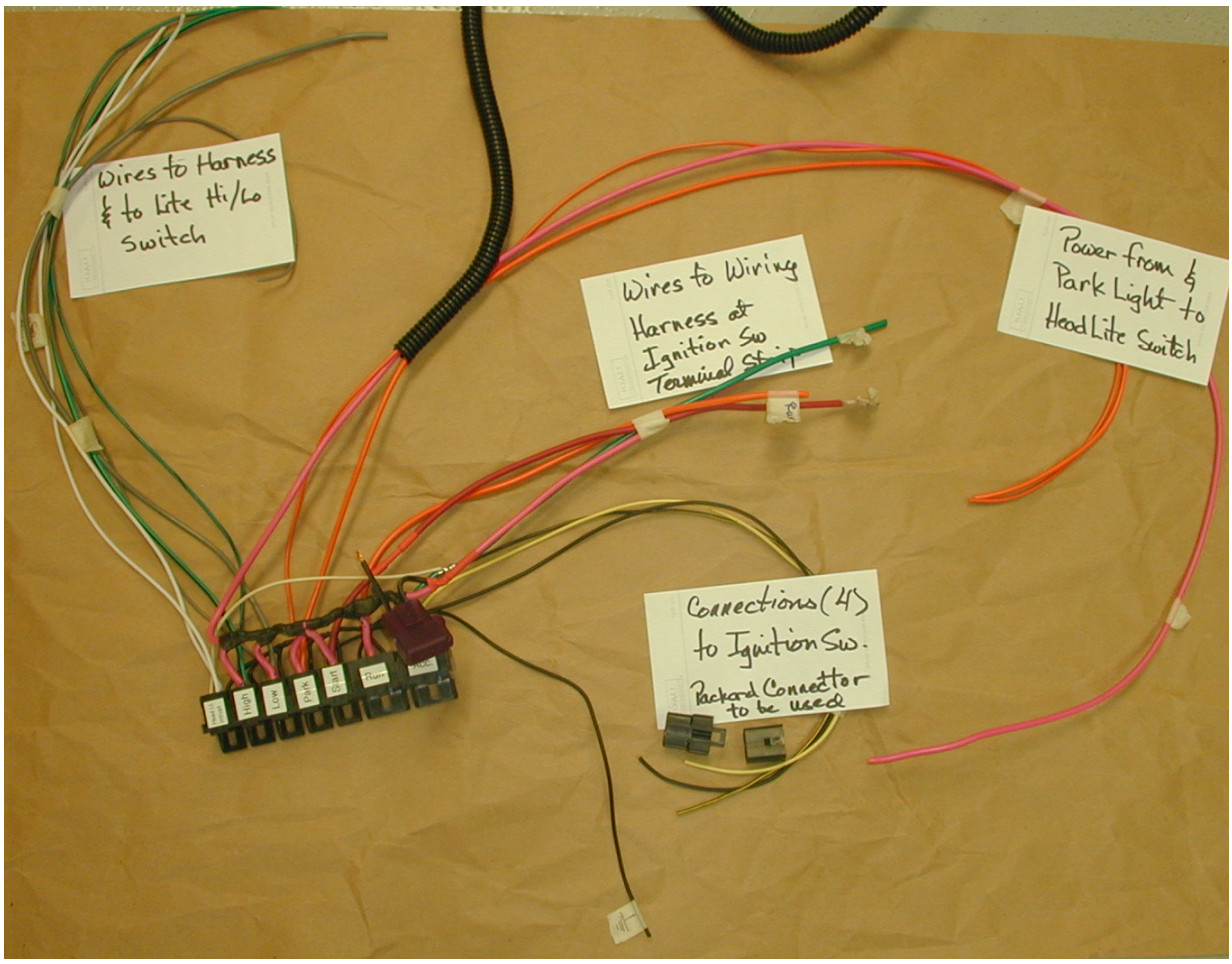


16) Typical Relay Installation - Cut the harness wire and attach the 10 or 12 gauge power wire (heavy line) from the relay's contacts (#5) to the harness side of the cut wire. The switch side of the cut wire connects to the 18 gauge control wire leading to terminal #1. Since the cut wire is green-black and the power and control wires are the same color, following the schematic is simplified. The ignition switch wires are already "cut" at the terminal strip. Just use power and control wires the same color as the wires to which they attach. Note - The Lite Interrupt relay (not shown in this diagram) simply breaks continuity of the white wire (far left of diagram) which now takes only control power to the Hi/Low switch.

This process was repeated for all the ignition switch and light switch relays. I selected wire the same color to match the cut harness wire to which I was connecting. This way troubleshooting is (hopefully) simplified. Stating the obvious, be

sure to cut the Hi/Low beam harness wires on the car-side of the big yellow connector, not the switch-side of the connector. That way, when the connector is disconnected, wires from the relay stay with the car's harness and the steering column with its ignition switch can be removed without cutting wires.

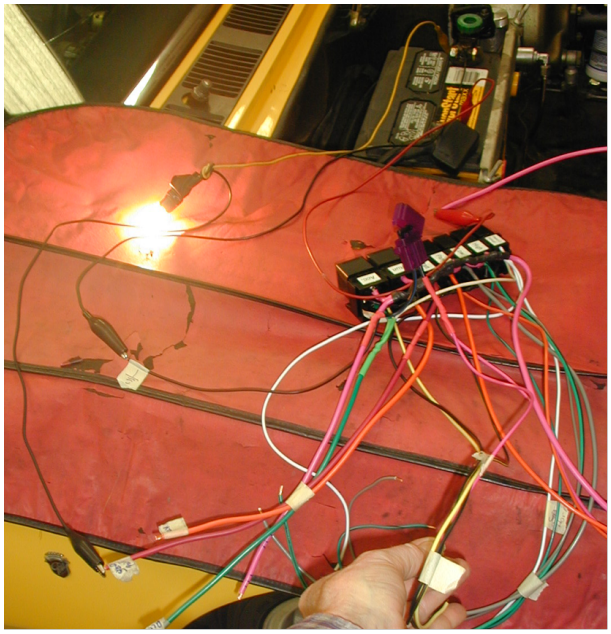
We now have 2 groups of wires
1) 8-wires going to the ignition switch, both the harness side (10ga. wires) and to the switch side (18ga. wires) plus 6-wires going to the Hi/Low beam switch, both the harness side (12ga. wires) and to the switch side (18ga. wires) and
2) 3-wires going to the parking rocker switch, both the harness side (10ga. pink power and 12ga. wires) and to the switch side (18 ga wires).



17) The wired relay module - I labeled the 3 bundles (the ignition switch wires are shown as 2 bundles)

I did not measure the length of each section of the harnesses which I made. Once installed, I cut very little off the ignition switch leads. I cut some off the headlight rocker switch leads. So, the lengths shown in the photo are pretty close. You can estimate their approximate lengths, when in doubt make it a few inches longer since wires are hard to stretch but easy to cut. Both the ignition switch and Hi/Low switches are close together and I ultimately ran and bundled them together.

INSTALLING THE RELAY MODULE



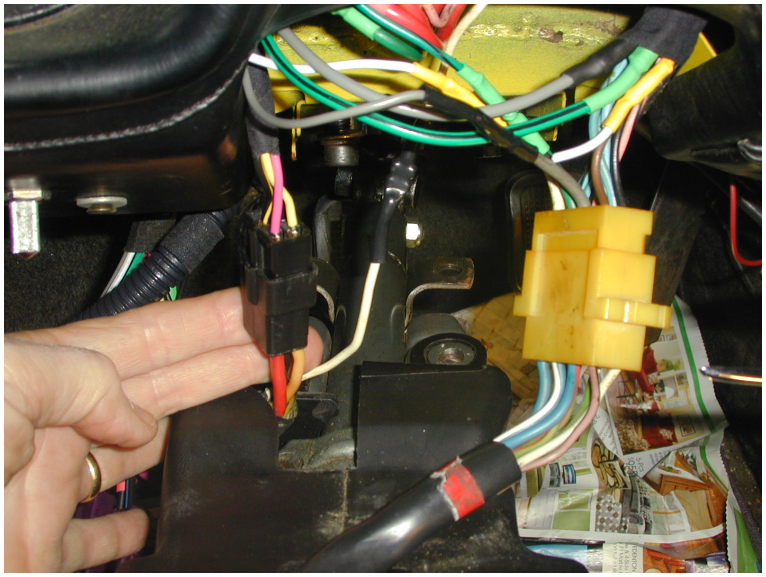
18) I took the module over to the car and did a bench test of all the circuits prior to installing it in the car. This tests all the relays and soldered terminations for correct operation. I used a test light made from a #1156 taillight bulb for my load.

Once assembly and testing of the relay module is completed and the wires are temporarily bundled, the relay module is raised up into place under the dash (I put it on a cardboard box) and the 1st bundle is run above the steering column. Half the bundle is then routed down toward the ignition and Hi/Low switches and the other half is routed toward the car end of the cut wiring harness. The 2nd longer bundle is routed over toward the head light rocker switch.

19) The Ignition and Hi/Low switch bundles coming down to the top of the steering column. The Harness-ends of the Ignition Switch wires are shown in the process of being soldered. The heat shrink has, not yet, been slid down over the soldered butt connector. The headlight wires above the yellow connector have not yet been cut. *Note* - masking tape is used to label the wires and butcher paper to protect the steering column.

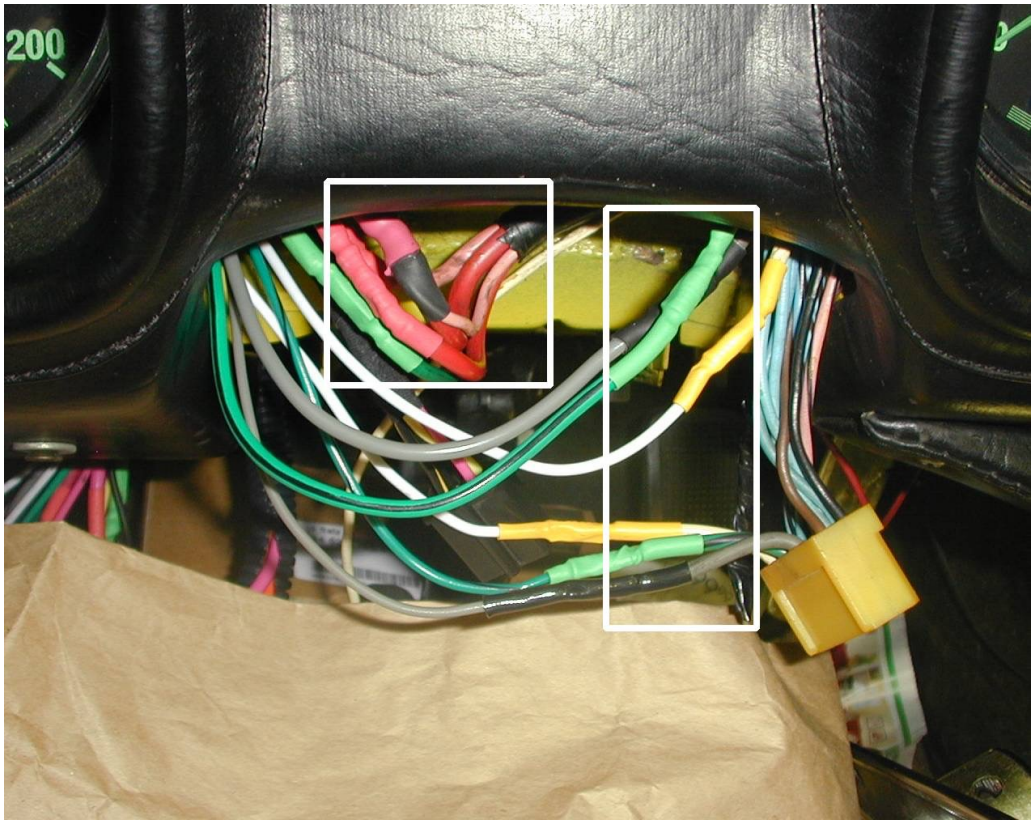
After removing the ignition switch terminal strip, the 10 gauge wire from the relay is cut to length and heat shrink tubing placed over the wire far away from the soldering heat. The harness-end of the matching color wire and relay wire are both stripped about 1/4". The two wire ends are crimped together with a butt crimp which makes soldering much easier. Yes, of course, I removed the insulation off the butt crimp before installing it so I could solder the crimped connection. I solder **every** connection & terminal, and when I use a crimp connection it is always soldered as well! Wait for it to cool and slide the heat shrink over the butt splice and heat it into place. Be careful not to overheat the dash (or anything) with the heat gun and take care with the soldering iron so you don't touch and melt the dash.

Repeat this process with the 18 gauge control circuit wires going to the ignition switch. I made it the same color as the wire already attached to the ignition switch (hopefully you made them color coded, you can now see how it helps). Now, the control circuit wires are terminated in a connector and the opposite side of the connector is attached to the wires coming from the ignition switch. Now, you can see why I made the relay module on the workbench to limit the amount of work done under the dash to a minimum. This same process is continued with the remaining 3 wires on the ignition switch. One of the 4 wires is the pink 10-gauge power wire supplying power to all the relays, or at least the ignition switch portion of the relay module. Back at the relay module the 1-Amp fuse is attached to this pink power buss providing constant control power to the ignition and light switches.



20) The 18-gauge control wires from the relay coils are routed to the new 4 pin Packard connector which connects them to the wires leading to the ignition switch. The Hi/Low beam relays are shown connected into the wiring just above the yellow connector. Note - the white wire has it's own connector.

The parking light relay is wired-in at the headlight rocker switch and the Hi/low relays are wired-in at the harness side of the big yellow connector. The procedure is the basically the same for all connections. Slide heat shrink over the relay's 12 gauge power wire and 18 gauge control wire of the same color of the wire you will cut. Once the harness wire is cut, butt crimp the power wire to the car side of the cut wire, solder, and cover it with heat shrink. Similarly, connect the control wire to the switch side of cut harness wire.



21) The left rectangle shows the power output of the ignition switch relays connected to the harness-end of our harness wires. The right rectangle shows the Hi/Low beam power wires connected to the harness-end of the cut wires *and* the control wires connected to the big yellow connector which leads to the steering column switch. Notice I got fancy by using colored heat shrink tubing obtained from Fry's Electronics.

We must also cut the white power wire going to the Hi/Low headlight switch at the big yellow connector. Continuity through this white wire is controlled by the interrupt relay, only turning ON when the car has Accessory power.

I ended up using the hole I drilled into the steering column sheet metal which I *optimistically assumed* I could use to mount my relays, Ha, Ha! I use it to attach the ground buss to the chassis. After building the wiring harness for the relay there was no way to easily mount the relay base to the sheet metal under the steering column. Too many stiff 10 gauge wires were in the way. I ended up "mounting" the relay module under the dash with Zip Ties. This is advantageous because you can snip the zip tie and, with the slack in the wires, the entire relay assembly will drop down a couple of inches to allow a relay to be changed. I found that it takes the strength of a gorilla to pull a relay out of its base, so allowing it to drop down greatly enhances it's replacement. The original concern, that a relay might vibrate out of its base if not positioned properly, is no longer an issue with me. It would *look* nicer if the relay module was mounted to the sheet metal, but not really practical. I will be the only one to ever see the module up under the dash. I now have comfort when using the lights and have a more reliable car. Now, if you desire, you can use this information to modify these and other switch circuits in your car.