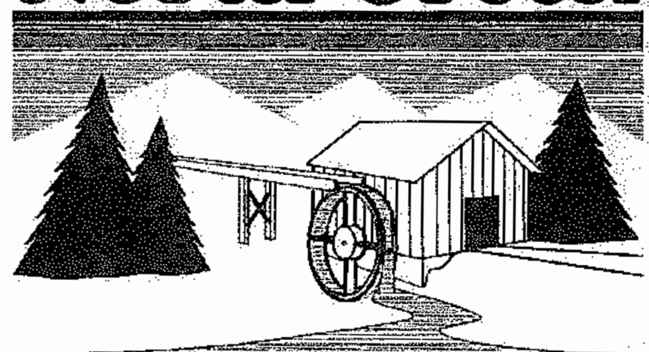
$5.00

North Creek



MUSIC SYSTEMS

Wiring Guide

Simply Better Technology

Dear Fellow Speaker Builder,

I would like to welcome you to the second edition of the *North Creek Music Systems Wiring Guide*. This publication has been written to explain in detail our method of crossover assembly, as well as to provide some standard methodologies for crossover assembly in general.

Our crossover philosophy, and consequently the material presented in the *Guide*, is indicative of our *system-oriented* approach to loudspeaker design. The two essential facts one should gain from reading this and our other publications are 1) a system is only as good is its poorest component. 2) the quality of the crossover is the most important element of a loudspeaker system.

It is my hope that the material within these pages provides you with valuable information, whether you are a first time speaker builder or a seasoned veteran. Our goal, as a company, is to make you a better speaker builder.

Happy listening!

George E. Short III
President

Making Connections

The two prevalent types of electronic assembly today are PCB (printed circuit board) and Hard Wiring.

In PCB assembly, each component is laid on the board, its leads are threaded through holes in the board, and each lead is connected to a thin conductive trace on the board by solder. Information between components is then carried by the trace. For computer systems and other low current applications, PCB's are fine; the losses at each connection point and between components is not objectively significant, and in most cases the end performance of the product is not affected by these losses.

Not so in loudspeaker crossover networks.

If one considers a simple case of two components connected via a PCB, on finds the following connections:

1) Output lead of Component 1 to solder.
2) Solder to PCB trace.
3) PCB trace to solder.
4) Solder to input lead of Component 2.

Four connections, each degrading the signal. The situation is further worsened by the fact that there is not mechanical connection whatsoever, and solder is a very poor conductor.

The same two components hard-wired:

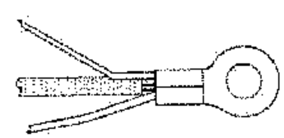
1) Output of component lead one with a good mechanical connection, coated in solder to prevent oxidation and hold the connection in place.

The rule for loudspeakers is:

"make a good mechanical connection first, then solder."

Types of mechanical connections:

The three most common types of mechanical connections in Crossover networks are "Cold Weld", "High Pressure", and "Low pressure, High Contact Area". As the goal of a good crossover connection is to put as much of component lead one in intimate electrical contact with component lead two, we will not even discuss the solder-only connection of PCB assembly.



CRIMP CONNECTION:
THREE LEADS TO RING TONGUE

A **Cold Weld** is by far the best electrical connection; this is when the actual conductors of lead one and lead two have flowed together. The key to making a cold weld is <u>pressure</u>, and the best way to make it is with a crimp. When we make this type of connection, it is done by inserting the two (or three or four...) component leads into a <u>non-insulated</u> crimp barrel, then crimping the barrel tightly shut. The "non-insulated crimp" section on regular wire cutter/strippers are usually only barely adequate for this task, and we suggest a dedicated heavy duty crimper (such as the Klein #1006, MCM part number 22-1795).

A **High Pressure** connection is one where the conductive surfaces are tightly pressed together, such as screw-down terminals, binding posts and driver quick connects. One must be careful with a quick-connect; if it is a little spread out, it should be closed slightly with pliers. Pressure is the key.

A **Low Pressure, High Contact Area** connection is the one which results from twisting wires together. The low pressure aspect of this connection is undesirable, therefore if one must twist one should twist tightly.

A special case of this type of connection is that between small gauge capacitor leads and tinned copper buss bar. To improve this connection, the lead should be wrapped tightly about the buss bar at least twice (preferably with pliers), then soldered immediately.

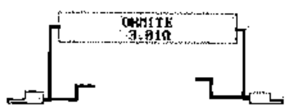
Of these three, the cold weld is best, so ***always crimp when you can.***

Treating Resistors Correctly

The function of a resistor is to transform a portion of the input signal into heat. Therefore, if a resistor is working properly, it will get hot.

The nature of most resistors is that their resistance increases as they get hotter. This is called a "positive temperature coefficient", or Tc. Most inexpensive resistors have a high Tc of several hundred parts per million per degree (ppm/°C), so their resistance changes by several percent as they heat up. Even the best resistors exhibit a Tc of 20-50 ppm/°C. It is common for resistors in crossover networks to get to 100°C or so during normal use.

To prevent the resistance change from becoming too large, the resistor must be mounted to dissipate heat. To do this effectively, a resistor should have air space on all sides.



RESISTOR MOUNTING

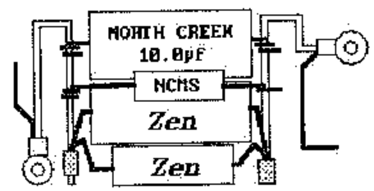
On North Creek crossovers, we bend the resistor leads such that the resistor body is suspended one half inch or so above the crossover board, and not near any other component. This mounting style allows the resistor to cool both by radiation and by conducting heat to the surrounding air.

Treating Capacitors Correctly

Capacitors are difficult to treat incorrectly because they are self-shielding; the capacitor outer wrap and conductive end coats form an almost complete shield.

None the less, one should orient capacitors such that stacks (paralleled capacitors) are placed with their bodies parallel and centered, while non-common caps are spread out and oriented perpendicularly.

Stacked (paralleled or bypassed) capacitors should be built up by connecting the capacitor leads to tinned copper buss bar, then using the buss bar to make the connection to the next component down the line. It is easiest to connect wire-lead capacitors to the buss bar using the twist-and-solder technique, although crimping with a crimp barrel also works well. For stranded lead caps, the best connection is made by inserting the buss bar and as many cap leads as will fit into a crimp barrel, then crimping and soldering. The buss bar can be bent (with pliers!) to orient the capacitors neatly on the board, while plenty of open conductor is left for making connections to other components. By using this method, current flowing to and from the capacitor bank is guaranteed a large gauge path.



CAPACITOR STACK

Clear silicone should be used to attach capacitor stacks together, and to adhere them to the crossover board. We suggest **GE Silicone II**, although most other 100% silicones should work. For large stacks, one should fill the region between the capacitor bodies with silicone first, then push them together and secure the stack with a rubber band. The stack should then immediately be secured to the board with more silicone and a single long tie wrap.

Treating Coils Correctly

Inductors, especially air core inductors, have a large stray magnetic field and will interact with each other at significant distances. The Speaker Builder article "Inductor Coil Crosstalk", by Mark Sanfilipo (SB 7/94), does an excellent job of demonstrating this phenomenon, and is well worth careful attention.

In short, to minimize inductor interaction, one must orient the inductor axis in *quadrature*; that is, the core of one should line up with the edge of the other. The visual analogy is *"if one looking through the core of one inductor can see the core of another, interaction will occur."*

Inductor stray magnetic fields also decrease with distance squared, so the farther apart two inductors are located, the better.

Inductor insulation is composed of a chemical which is bonded to the copper. The easiest way to strip this is to **grind** it off by clamping the lead in a small vise and grinding off the insulation with a drill and oxide grinder. In a pinch, one can also use a drywall knife and razor blade to scrape off the insulation.

If the inductor lead is to be attached to buss bar, one should strip the end and use a crimp barrel. 10 AWG crimp barrels will fit a 14 AWG buss bar and 14 AWG inductor lead. For larger gauge inductors, the steel crimp barrels available at most hardware stores work well.

Lastly, for a woofer section positive input, one should bring the inductor lead all the way back to the red binding post and terminate it in a ring tongue. Color code the connection with red heat shrink tubing.

The Crossover Board

It is strongly suggested that individual sections of the crossover network are wired on their own crossover boards.

For building a crossover, the best material we have found is ¼" pegboard. The pegboard hole pattern is a 1" x 1" matrix, which clearly defines some basic layout criteria for the crossover components.

Because we use ring tongue crimp connectors to make both wire-to-component connections and component-to-component connections, the ring tongue becomes both the electrical connector and the means of securely attaching the connection point to the crossover board.

The attachment is made by placing the hole in the ring tongue over a hole in the pegboard, running a #10/32 brass flat head machine screw up through the hole, and securing with a brass hex nut. The screw threads are then coated in red nail polish to assure the nut does not loosen. To make sure the rear of the board is flat, we countersink the pegboard hole prior to assembly.

CROSSOVER BOARD
WITH ATTACHED CONNECTION

This method has the following advantages:

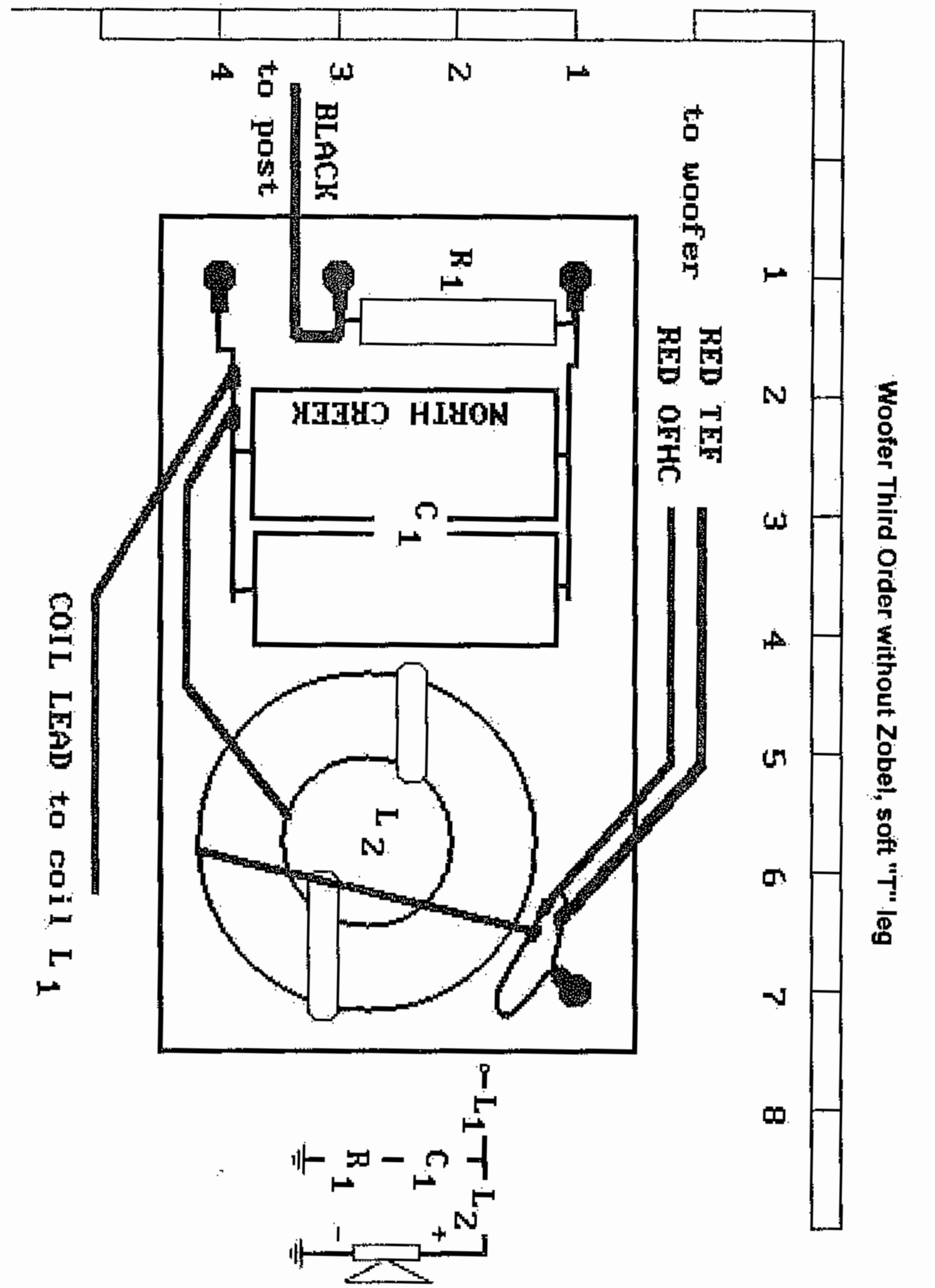
1) Wires leading to components are securely attached to the *crossover board*, not the component leads. If a wire is pulled, there is still no danger of breaking a connection or injuring a crossover component.
2) Heavy components, such as large capacitor stacks and inductors, are firmly attached by their leads.
3) Because both leads of each resistor is securely anchored to the crossover board, the leads can be bent such that the resistor body is ½" or so above the board and not in contact with any other components. This assures the resistor will cool properly.

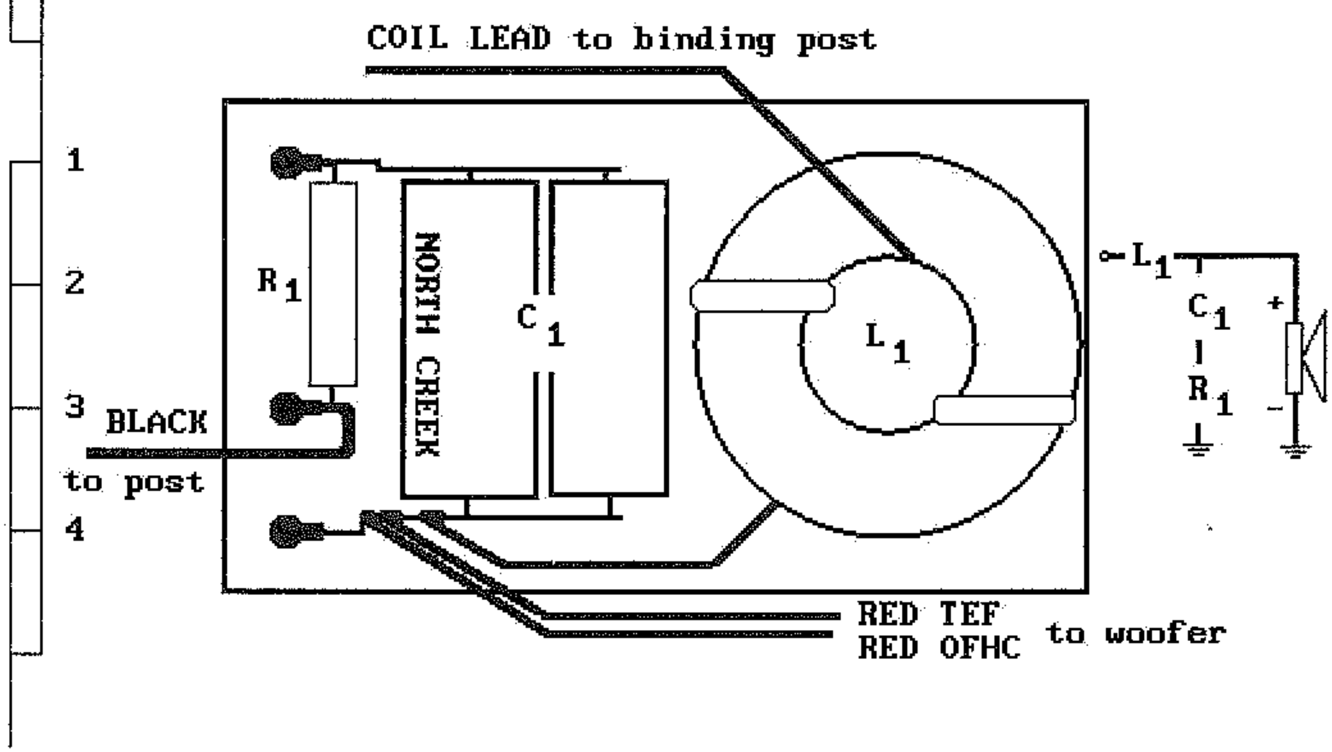
Other assembly notes:

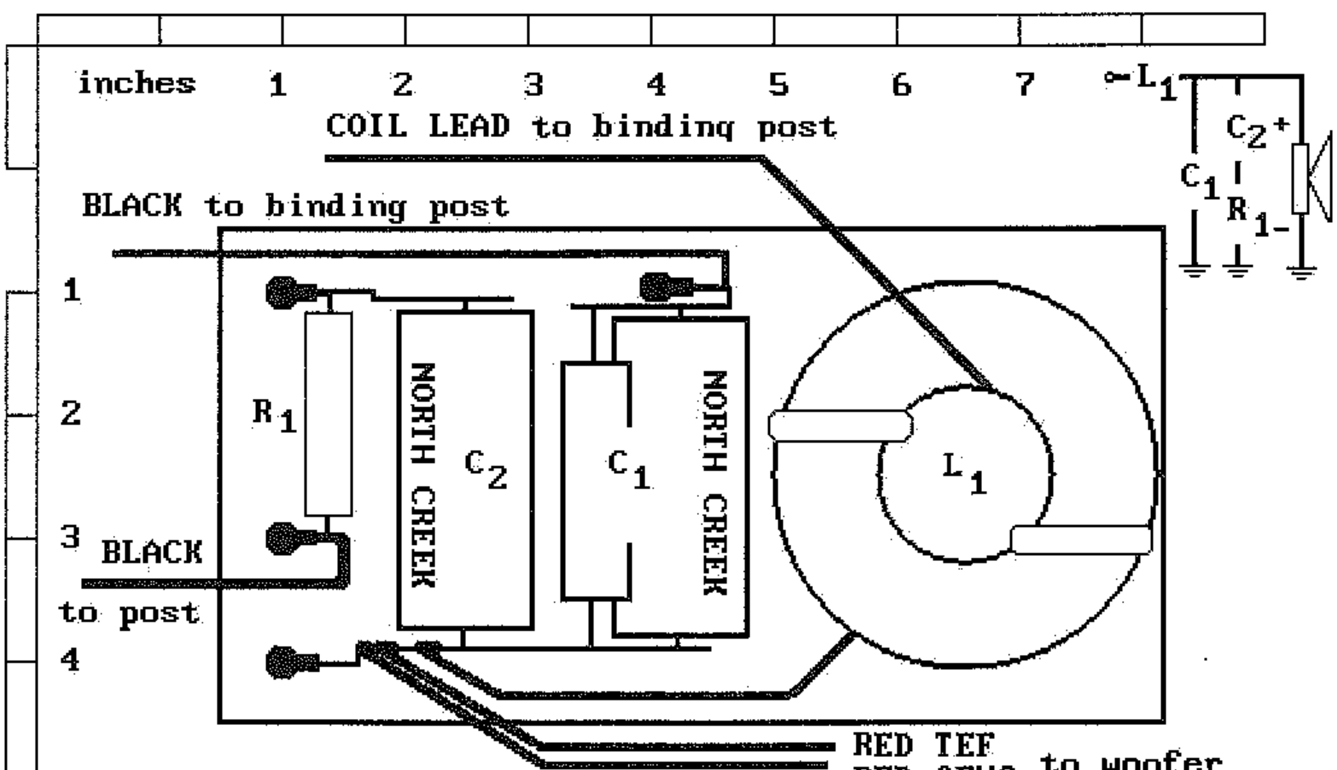
Clear 100% Silicone and tie wraps should be used to attach capacitor banks to the board.

To attach inductors, one should line up the inductor core over *four* pegboard holes, then run tie wraps down through these holes and back up along the outside edge of the inductor. The inductor should then be removed (the tie wraps will stay put) and its base covered with a bead of clear silicone adhesive. The inductor can then be put back into place and the tie wraps closed and tightened to secure it. Only then should the electrical connections be made.

Make sure resistor bodies are not touching any other component. This assures they will cool properly.




COIL LEAD to binding post
1
2
3
4
R1
BLACK
to post
NORTH CREEK
C1
L1
RED TEF
RED OFHC
to woofer
C1
R1
+
-


inches
1
2
3
4
5
6
7
COIL LEAD to binding post
BLACK to binding post
R1
BLACK
to post
NORTH CREEK
C2
C1
NORTH CREEK
L1
RED TEF
to woofer
C2
C1
R1
+
-

North Creek

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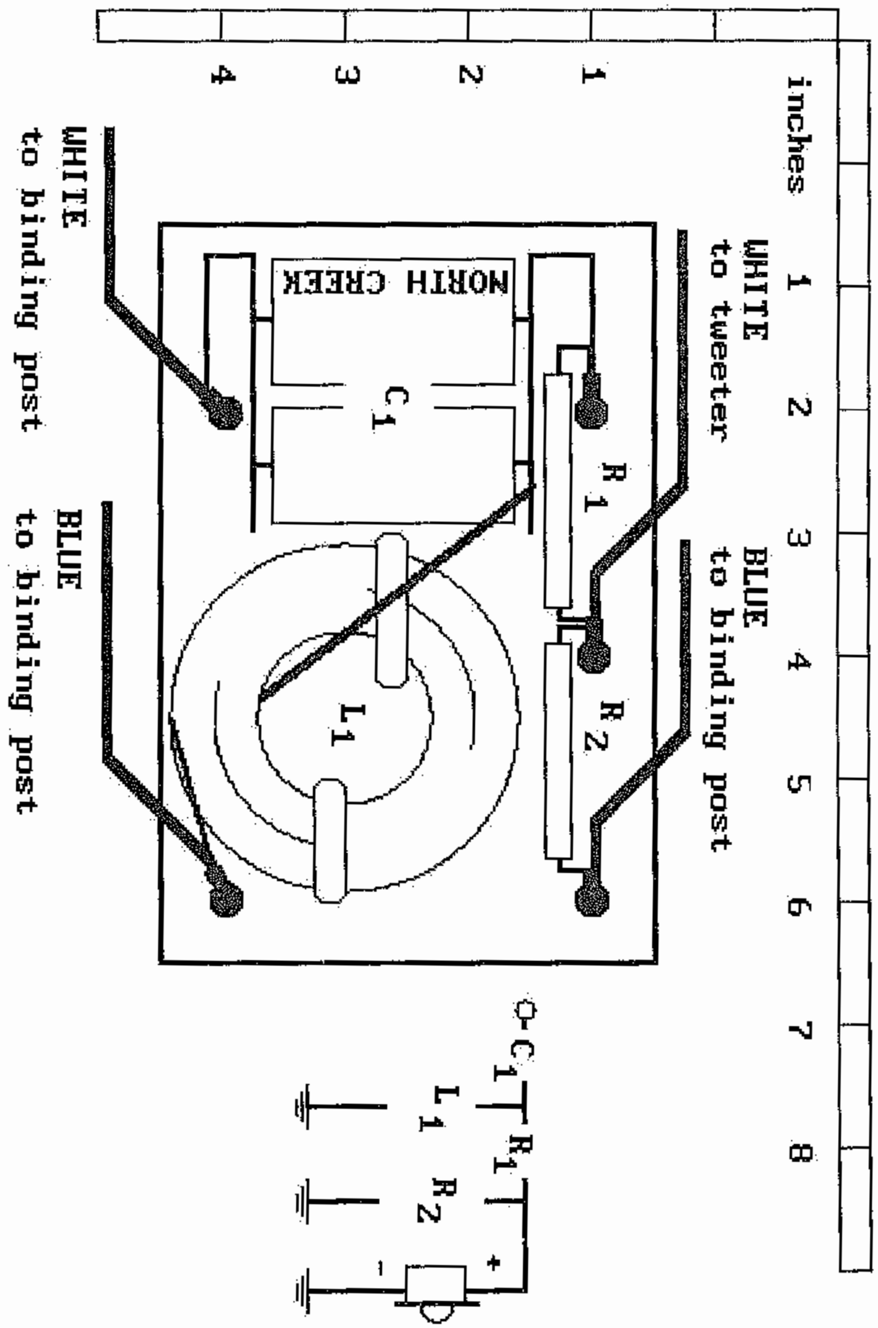


Tweeter Second Order with L-Pad

Star Grounding

Star grounding is "providing a unique electrical path to a main ground point for each element tied to ground." It is called "star" because the main ground point (usually the black binding post) ends up having many wires running to it, resembling a star. In a loudspeaker, this means that *every* crossover component tied to ground has its own wire leading to the black binding post.

To extend the analogy, one should also make every effort to "star input", hence the advent of bi- and tri-wiring. In multi-wired systems, the positive of each crossover section is tied directly and uniquely to the amplifier output terminal, and each negative binding post acts as a star ground for its particular crossover section.

Although it costs a little more to wire, star grounding (and star inputting) usually leads to far better imaging, superior clarity, and a much lower noise floor.

Standard Wiring

All North Creek products are wired according to the following color code:

Driver Terminal	Color
Woofer +	Red
Woofer -	Black
Midrange 1 +	Yellow
Midrange 1 -	Green
Midrange 2 +	Orange
Midrange 2 -	Brown
Tweeter +	White
Tweeter -	Blue

Note that in this color code scheme, within each pair, *the darker color is always negative*.

Also note that the color always refers to the __driver__ terminals, not the binding posts. __The binding post color pairing is the same, but the code is by color coded tape or shrink-tube at the connector to the binding post.__ We use colored heat shrink tubing.

Lastly, when bi-wiring, North Creek binding posts follow the same color code; Red and Black for the woofer, White and Blue for the tweeter. Again, the darker color is always ground.

Making Cables

When using a separate, external cabinet to house the crossover network, the need arises to make a dedicated crossover-to-driver cable which maintains the crossover network color code. The cable we manufacture for this purpose is made from a combination of Tef-Flex AG 14 AWG wire for the tweeter and Lex 10 AWG OFHC wire for the woofer, the same as used for our loudspeaker internal wiring. The color code we use matches both the crossover network wiring and binding post colors.

Variations of the cable can be made to suite almost any purpose. The terminations we use are spade lugs that attach to our standard binding posts; however, we have also terminated the cable in Neutric SpeakOn(tm) connectors, 4-pin BNC's, etc. Rumor has it terminating both ends with spades also makes a nice speaker cable, although we haven't tried it.

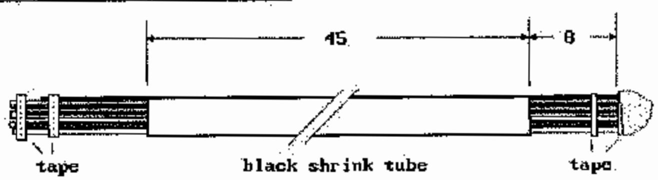
All of the materials needed to construct these cables are available through our regular catalog. If you prefer to experiment with other types of wire, the same basic procedure should be followed and has worked well for us on many occasions.

The example below provides a 14AWG path to the tweeter and a 10AWG path to the woofer. The example is for a single four foot length.

Materials:

6'	Red Lex 10 AWG OFHC	5"	3/8" Red Shrink Tube
6'	Black Lex 10 AWG OFHC	5"	3/8" Black Shrink Tube
6'	White TefFlex AG	5"	3/8" White Shrink Tube
6'	Blue TefFlex AG	5"	3/8" Blue Shrink Tube
4	Big Spade Jr(tm) terminals	3'	Silver Solder
5'	½" Black Shrink Tube	4'	Black Mesh Cable Jacket

Basic Cable and Inner Jacket Assembly:



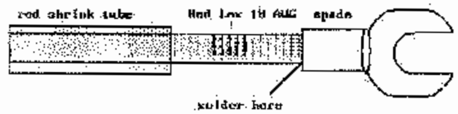
(Fig. 1)

1) Align all 4 of the wires into a bundle and tape each end together tightly with electrical tape. Apply an additional band of tape 2" from each end.
2) Wrap electrical or PVC tape over one end such that no wires are protruding. This must be smooth as it will be forced through the black shrink tube. PVC tape works best because it is inherently slippery.
3) Cut 45" from the ½" diameter black shrink tube.
4) Slide the black shrink tube over the wire bundle and gently push the bundle all the way through.
5) Align the shrink tube over the wire bundle such that 8" of wire sticks out of one end (Fig. 1).
6) Shrink the shrink tube with a heat gun. ***We suggest you wear heavy leather gloves while doing this, as the shrink tube gets quite hot.***

Note: Some manufacturers feel that twisting the cable results in better sound. This is definitely true of long wires in regions of large stray fields, such as inside a tube amp. The benefits of twisting speaker cable is questionable. If twisting is required, it is most easily accomplished between steps 5) and 6) above. Tie the long leads around a post, feed the short leads into a variable speed drill, apply tension to the cable and slowly twist it at low speed with the drill. Shrink the jacket about the twisted cable before the drill is removed.

Termination Procedure:

1) Cut one 6" section from the remaining black shrink tube and slide it over the cable bundle, past the loose wiring, and down to the center of the cable.
2) Line up the 8" leads side-by-side and trim them appropriately such that they are exactly the same length.
3) Strip the red lead and insert it into the crimp region of a single Big Spade Jr. spade terminal. Crimp the connection (Fig. 2).
4) Repeat step 3) for the black, white and blue leads.



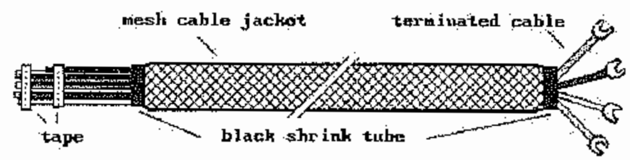
(Fig. 2)

5) Solder the leads to the spades using silver solder. The best place for the solder joint is the rear of the Big Spade Jr. where the wire enters. Be careful not to let any solder or flux flow onto the plate of the spade.
6) Slide the 5" Red shrink tube over the spade and down the length of the red lead. Do the same for the Black, White, and Blue leads. Slide the tubes back up over the crimping region of the spade (Fig. 3), and make sure the crimping region is completely covered, as you will not get a second chance. If all is well, shrink the tubes.

(Fig. 3)

7) Pull the 6" section of black shrink tube over the edges of the color-coded leads such that 4" of each lead remains free. This section of tube should extend 1" over the colored leads and 1" to 2" over the wire bundle. Shrink this section. This is now a cable.

Outer Jacket:



(Fig. 4)

1) Cut 1" of black shrink tube and slide it all the way down the cable to the spade lugs.
2) Slide the 4' section of mesh cable jacket over the cable. Align the end ½" from the end of the black inner jacket (at the spade lug end).
3) Slide the 1" section of black shrink tube over the end of the mesh jacket. If the mesh is slightly frayed, tape it off with black electrical tape, then slide the 1" shrink tube section over it. Carefully align the shrink tube such that it exactly matches the termination of the inner jacket.
4) Very carefully and quickly, shrink this section in place. ***If the heat is on this junction too long it will melt the mesh cable jacket, so be quick!***
5) Pull the jacket tightly over the cable by working from the spade lugs back. When the jacket lies correctly, terminate the loose end with an additional 1" piece of black shrink tube.

The loose leads are for connection to the crossover network. We make these connections through the bottom of the crossover cabinet, by drilling an opening in the bottom and pulling the cable through.

CROSSOVER ENGINEERING BOARD

For those who do a lot of crossover optimization and need the ability to change crossover components quickly, this external breadboard is the ticket. The board is compact and simple to use, and gives the designer the ability to quickly assemble a test crossover and easily change any component in the circuit using only a 3/8" nut driver. One can add sections simply by making the board longer. We use precisely this board in our own listening lab.

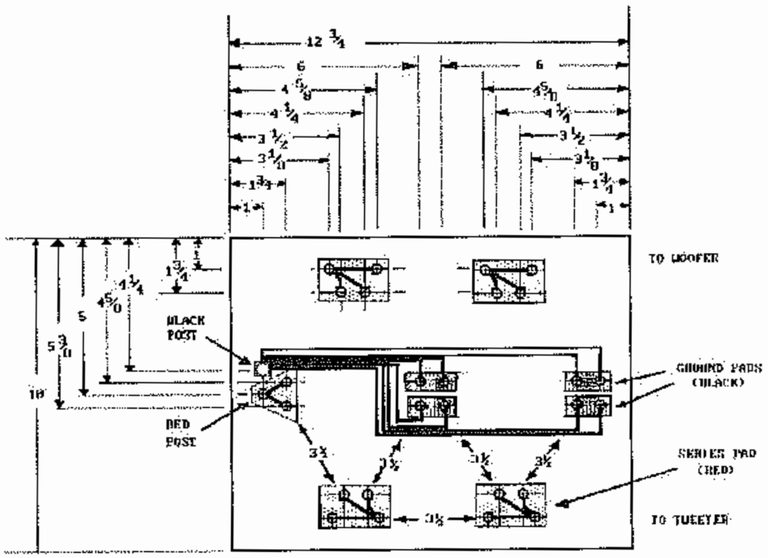
Required Materials

2	10" x 12.75" x ½" plywood,
8	Big Toe Jr. spikes
52	10/32 x 1" brass machine screws
100	10/32 brass nuts

Electrical Materials

18 to 14 AWG solid core wire

2	red binding posts (4 to bi-wire)
2	black binding posts (4 to bi-wire)
60	#10 ring tongues



EXTERNAL CROSSOVER ENGINEERING BOARD

Instructions:

1) Drill all holes. Spikes go in the corners.
2) Outline and paint red and black areas.
3) Install all screws in the red ares, connecting all within each area together on the topside of the board with ring tongues and wire.
4) Install the red binding post, connecting it to the two screws in its pad.
5) Install black binding post and all screws in the black areas, star grounding to the black binding post.
6) Instell spikes.

All of the extra nuts are used to tighten down the crossover components.

Note: To bi-wire, just add another post and seperate the positive and ground sections.

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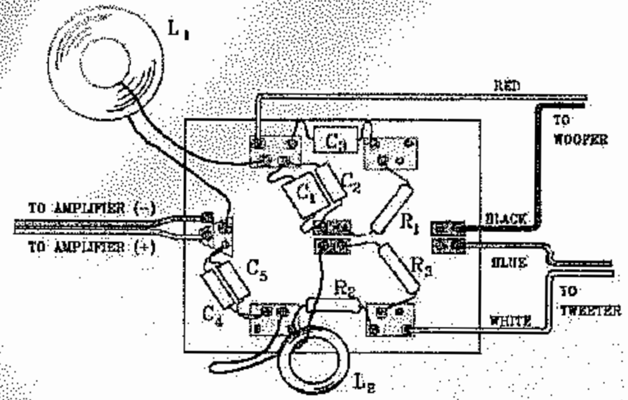
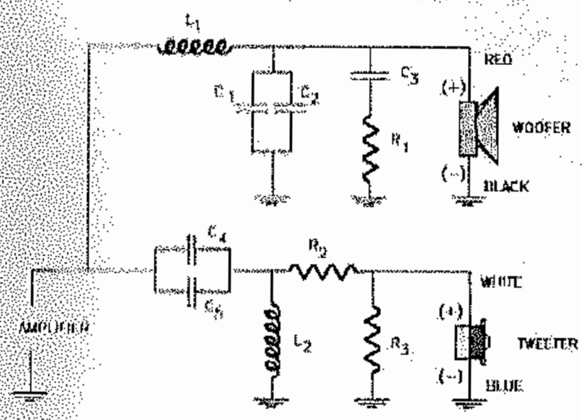


EXTERNAL CROSSOVER BOARD WITH PROTOTYPE FILTER



SCHEMATIC OF PROTOTYPE CROSSOVER

The diagrams above show a prototype crossover and schematic on the engineering board. The filter is a symmetrical second order network with a bypassed shunt capacitor and impedance compensation on the woofer, and stacked series capacitors and output attenuation on the tweeter. Note that even though this circuit requires 10 elements, all of them are accessible and can be easily changed. Even the phase of the tweeter can be reversed by exchanging wire positions on the board.

Notes:

- To use this board, each of the "lab" crossover components must be terminated with #10 ring tongues. While this requires a small initial investment in tongues and a lot of crimping, it saves a tremendous amount of time.
- Each connection in a series pad (red area) is precisely 3½" from its corresponding connection in the ground (black) or following series pad. Once the component leads have been bent to 3½", they will work anywhere on the board.
- The easy way to run the wiring from the board to the drivers is through a bi-wired cup. Use white and blue binding posts for the tweeter and red and black posts for the woofer. The breadboard should be placed on the floor beside the loudspeaker and connected with a dedicated cable.