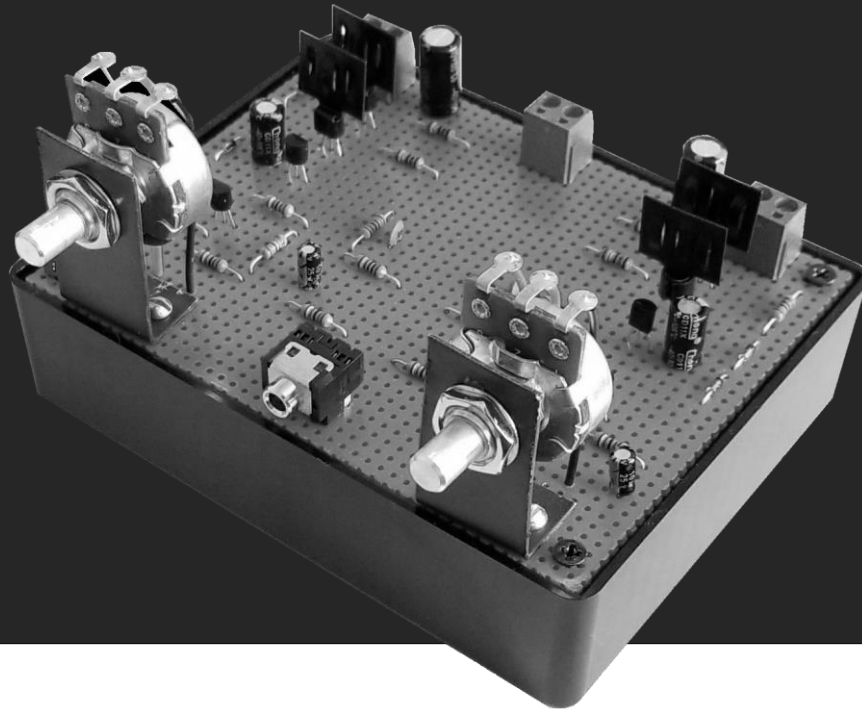


# *Science Fair*<sup>TM</sup>

INSTRUCTION MANUAL PRICE: 50¢



## **STEREO AMPLIFIER**

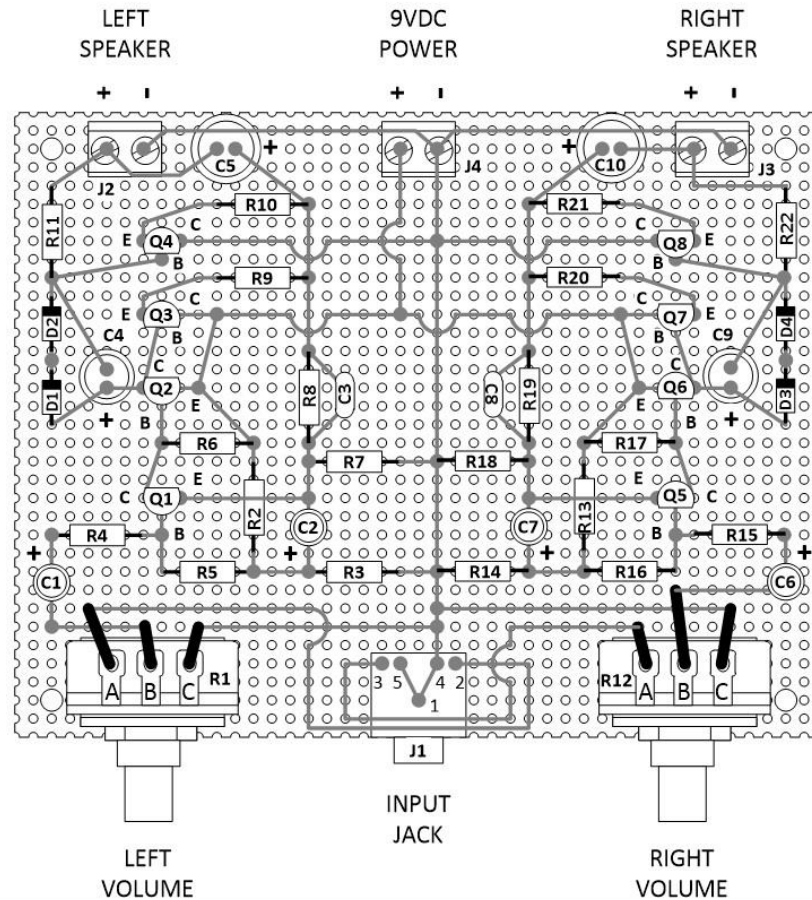
**Catalog Number 28-113**

As you have probably noticed, music seems unnatural when played through only one speaker. Stereo recordings are specially mixed in the studio to make sounds seem to originate from multiple locations in a room. By using two separate amplifiers and speakers instead of only one the sound seems to come from many directions just as it would if the band were actually there. This stereo amplifier can reproduce sound with exciting realism.

Structurally, the amplifier consists of two identical audio amplifying circuits. Each audio amplifier is equipped to amplify a small signal and drive a permanent magnet speaker. Each circuit consists of two direct coupled transistors for voltage amplification and a matched pair of complementary transistors for power output. Wide frequency response with low distortion is achieved in this stereo amplifier due to the use of the direct-coupled transistor circuit.

# FIG. 1 – PICTORIAL DIAGRAM

# TOP VIEW



## PARTS LIST

Qty	Identification	Symbol	Vendor	Vendor Part	Price
2	1Meg Ohm Potentiometer	R1, R12	Mouser	PDB241-GTR02-105A2	\$ 3.23 ea
2	68K Ohm 1/4W 1% Resistor	R2, R13	Mouser	MFR-25FRF52-68K	\$ 0.12 ea
6	15K Ohm 1/4W 1% Resistor	R3-R5, R14-R16	Mouser	MFR-25FRF52-15K	\$ 0.12 ea
2	1.5K Ohm 1/4W 1% Resistor	R6, R17	Mouser	MFR-25FRF52-1K	\$ 0.10 ea
2	1K Ohm 1/4W 1% Resistor	R7, R18	Mouser	MFR-25FBF52-1K5	\$ 0.10 ea
2	7.5K Ohm 1/4W 1% Resistor	R8, R19	Mouser	MFR-25FBF52-7K5	\$ 0.10 ea
4	0.47 Ohm 1/4W 1% Resistor	R9-R10, R20-R21	Mouser	MFR-25FBF52-0R47	\$ 0.46 ea
2	680 Ohm 1/4W 1% Resistor	R11, R22	Mouser	MFR-25FBF52-680R	\$ 0.12 ea
4	10uF 25V Electrolytic Capacitor	C1-C2, C6-C7	Mouser	USR1E100MDD1TE	\$ 0.15 ea
2	100uF 25V Electrolytic Capacitor	C4, C9	Mouser	ULD1E101MED1TD	\$ 0.20 ea
2	1000uF 25V Electrolytic Capacitor	C5, C10	Mouser	UVR1E102MPD1TD	\$ 0.44 ea
2	330pF 50V Ceramic Capacitor	C3, C8	Mouser	D331K20Y5PL6TJ5R	\$ 0.10 ea
4	1N4148 Diode	D1-D4	Mouser	512-1N4148	\$ 0.10 ea
4	2N3904 NPN Transistor	Q1, Q3, Q5, Q7	Mouser	2N3904BU	\$ 0.20 ea
4	2N3906 PNP Transistor	Q2, Q4, Q6, Q8	Mouser	2N3906BU	\$ 0.23 ea
1	1/8" Stereo Jack	J1	Mouser	490-SJ1-3545N	\$ 1.31 ea
3	2-Position Terminal Strip	J2-J4	Mouser	1546217-2	\$ 0.64 ea
4	#4-40 Hex Nut		Mouser	7230-3	\$ 0.08 ea
4	#4-40 1/4" Machine Screw		Mouser	534-9900	\$ 0.11 ea
4	#4 Lock Washer		Mouser	7230-2	\$ 0.06 ea
2	Volume Knob		Mouser	506-PKD70B1/4	\$ 4.15 ea
1	Project Box		Mouser	1591GSBK	\$ 5.33 ea
1	4" x 5" Perfboard		Mouser	7100-45	\$ 4.68 ea
4	TO-92 Heat Sink		Mouser	575200B00000G	\$ 0.69 ea
1	9V Battery Clip		Mouser	534-235	\$ 0.74 ea

Approximate cost for all parts is \$40 from Mouser (not including tax and shipping). With a reasonably stocked parts box, or purchasing bulk assortment kits from Amazon, eBay, or UxCell.com the cost can be reduced to around \$18.

## STEP-BY-STEP WIRING AND ASSEMBLY DIRECTIONS

Be sure to carefully follow all the directions. Do one step at a time and then check off the step in the box provided. Before beginning, read over the enclosed page labeled "Construction Hints".

NOTE: Pay particular attention to the physical location of the transistor leads and proper orientation of the electrolytic capacitors. Improper connections to these components can cause their destruction.

- ( ) Check the parts list to see that everything listed is included. Check each step as you progress (✓).
- ( ) Place the pictorial diagram (Figure 1) near the perfboard so that it can be used as a guide for exact placement of parts. The gray lines in the pictorial diagram indicate wires that are mounted under the perfboard. The solid lines indicate components and wires mounted on top of the perfboard.
- ( ) Expand holes in the perfboard for the two (2) mounting brackets and install using #4-40 screws, lock washers, and hex nuts as indicated in Fig. 2.
- ( ) Run a bare wire between the negative (-) pins of J2, J4, and J3. Twist one loop of wire around each pin to keep the wire secure. Solder the negative (-) pins of J2 and J3 only.
- ( ) Run a bare wire between the negative (-) pin of J4 and pins 1, 4, and 5 of J1. Twist one loop of wire around each pin to keep the wire secure and then solder. The bare wires are the GROUND BUS for the amplifier.

You are now ready to construct the left channel amplifier.

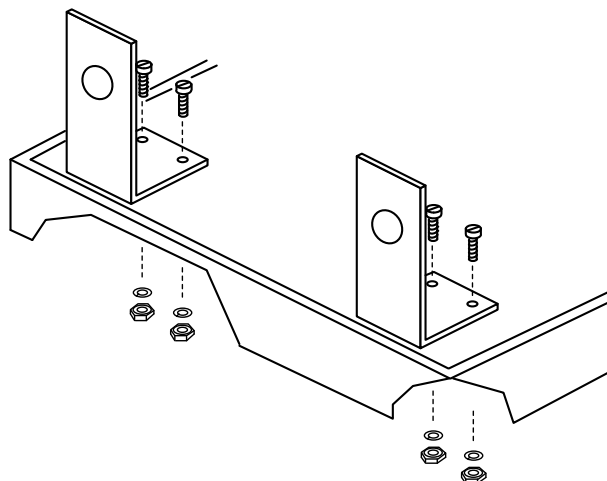


FIGURE 2

- ( ) Mount the two (2) 1 Meg volume controls, R1 and R12 in their respective brackets as shown in Fig. 3 using the supplied flat washers and hex nuts. Read the lugs A, B, and C in a clockwise direction while looking at the front of the volume controls as shown in Fig. 3.
- ( ) Straighten the pins of J1 so that they can more easily be inserted into the perfboard. Install J1 through J4 in the positions indicated, spreading the leads slightly so that the connectors stay in place when the perfboard is turned over.

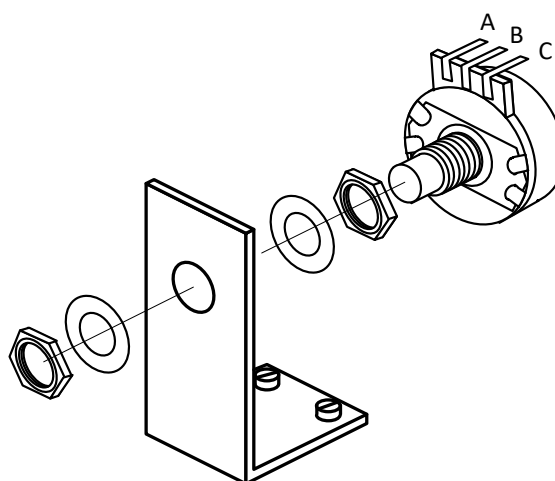


FIGURE 3

- ( ) Run an insulated wire from solder lug A on the left potentiometer R1, to Pin 2 on stereo input connector J1. Strip 1/8" insulation from each end and solder.
- ( ) Run an insulated wire from solder lug C on the left potentiometer R1, to the bare wire GROUND BUS. Strip 1/8" insulation from each end and solder.
- ( ) Insert 10uF capacitor C1 as shown in Fig. 1. Bend the leads slightly outward to keep the capacitor in place.
- ( ) Run an insulated wire from solder lug B on the left potentiometer R1, to the negative (-) lead of C1. Strip 1/8" insulation from each end and solder.

- ( ) Insert 15K resistor R4 as indicated in Fig. 1. Solder one end to the positive (+) lead of capacitor C1. Trim both leads of C1 and R4.
- ( ) Insert 15K resistor R3 as shown in Fig. 1. Solder one end to the bare wire GROUND BUS. Trim the soldered lead of R3 only.
- ( ) Insert 1K resistor R7 as shown in Fig. 1. Solder one end to the bare wire GROUND BUS. Trim the soldered lead of R7 only.
- ( ) Insert 15K resistor R5 as shown in Fig. 1. Bend the leads of R3 and R5 together and trim as needed, then solder R5 to R3.
- ( ) Insert 68K resistor R2 as shown in Fig. 1. Bend one lead of R2 over the leads of R3/R5 and solder. Trim the soldered lead of R2.
- ( ) Insert 1.5K resistor R6 as shown in Fig. 1. Wrap the lead of R6 one turn around R2 and solder. Trim the soldered lead of R6 only. Do not trim R2 yet.
- ( ) Insert 7.5K resistor R8 as shown in Fig. 1. Bend the leads of R8 outward slightly to keep it in place.
- ( ) Insert 330pF capacitor C3 as shown in Fig. 1. Wrap each lead one time around the leads of R8 and solder. Trim the leads of C3 only.
- ( ) Insert 10uF capacitor C2 as shown in Fig. 1. Bend the positive (+) lead of C2 over the leads of R3/R5 and solder. Trim the positive lead of C2 only.
- ( ) Bend one lead of R8 toward R7 and C2. Wrap one turn around R7 and the negative (-) lead of C2, then solder R8 to R7/C2. Trim the lead of R7 and R8 only.
- ( ) Insert 2N3904 transistor Q1 as shown in Fig. 1. Bend the base (B) lead toward R4/R5, the collector (C) lead toward R6, and the emitter (E) lead toward C2.
- ( ) Solder the base (B) lead of Q1 to resistors R4 and R5. Trim leads.
- ( ) Bend the negative (-) lead of C2 toward the emitter (E) lead of Q1 and solder. Trim leads.
- ( ) Solder the collector (C) of Q1 to R6 and trim Q1 lead only.
- ( ) Insert 1000uF capacitor C5 as shown in Fig. 1. Bend leads slightly outward to keep C5 in place.
- ( ) Wrap the negative (-) lead of C5 around the positive (+) pin of J2 but do not solder yet.
- ( ) Insert 0.47 Ohm resistor R10 as shown in Fig. 1. Bend leads slightly outward to keep R10 in place.
- ( ) Insert 0.47 Ohm resistor R9 as shown in Fig. 1. Bend leads slightly outward to keep R9 in place.
- ( ) Run a bare wire between the positive (+) lead of C5, to R10 and R9, and then to R8. Solder the wire to C5, R10, R9, and R8. Trim all leads.
- ( ) Insert 680 Ohm resistor R11 as shown in Fig. 1. Wrap one lead around the positive (+) pin of J2 and solder. Trim leads.
- ( ) Insert 1N4148 diodes D1 and D2 as shown in Fig. 1. Twist the anode lead of D2 to the cathode lead of D1 and solder. Trim leads.
- ( ) Wrap the cathode lead of D2 around R11 (one turn) and solder. Trim soldered D2 lead only.
- ( ) Insert 100uF capacitor C4 as shown in Fig 1. Connect the negative (-) lead of C4 to R11/D2 and solder. Trim leads for D2 and C4 but do not trim R11 yet.
- ( ) Wrap the anode lead of diode D1 to the positive (+) lead of C4 but do not solder yet.
- ( ) Insert 2N3906 transistor Q2 as shown in Fig. 1. Connect the base (B) lead to R6 and solder. Trim leads.
- ( ) Connect R6 to the emitter (E) lead of Q2 and solder. Trim soldered lead of R6 only.
- ( ) Connect the collector (C) lead of Q2 to the positive (+) lead of C4 and solder. Trim soldered lead of C4 only.
- ( ) Insert 2N3904 transistor Q3 as shown in Fig. 1. Bend the base (B) lead of Q3 and the collector (C) lead of Q2 together and solder.
- ( ) Connect R9 to the emitter (E) lead of Q3 and solder. Trim leads.

- ( ) Using a short piece of bare wire, connect the emitter (E) lead of Q2 with the collector (C) lead of Q3. Solder the emitter (E) lead of Q2 but do not solder the collector (C) lead of Q3 yet.
- ( ) Run an insulated wire between the positive (+) lead of J4 to the collector (C) lead of Q3. Strip 1/8" from each end. Solder the insulated wire to the collector (C) lead of Q3 and trim leads. Wrap the other end to the positive (+) lead of J4 but do not solder yet.
- ( ) Insert 2N3906 transistor Q4 as shown in Fig. 1. Attach the unsoldered lead of R11 to the base (B) lead of Q4 and solder.
- ( ) Connect R10 to the emitter (E) lead of Q4 and solder. Trim leads.
- ( ) Run an insulated wire from the collector (C) lead of Q4 to the GROUND BUS. Trim 1/8" insulation from each end and solder.
- ( ) Insert 15K resistor R16 as shown in Fig. 1. Bend the leads of R16 and R14 together and trim as needed, then solder R16 to R14.
- ( ) Insert 68K resistor R13 as shown in Fig. 1. Bend one lead of R13 over the leads of R14/R16 and solder. Trim the soldered lead of R13.
- ( ) Insert 1.5K resistor R17 as shown in Fig. 1. Wrap the lead of R17 one turn around R13 and solder. Trim the soldered lead of R17 only. Do not trim R13 yet.
- ( ) Insert 7.5K resistor R19 as shown in Fig. 1. Bend the leads of R19 outward slightly to keep it in place.
- ( ) Insert 330pF capacitor C8 as shown in Fig. 1. Wrap each lead one time around the leads of R19 and solder. Trim the leads of C8 only.
- ( ) Insert 10uF capacitor C7 as shown in Fig. 1. Bend the positive (+) lead of C7 over the leads of R14/R16 and solder. Trim the positive lead of C7 only.

You have completed the wiring for the left channel amplifier and are now ready to construct the right channel amplifier.

- ( ) Run an insulated wire from solder lug A on the right potentiometer R12, to Pin 3 on stereo input connector J1. Strip 1/8" insulation from each end and solder.
- ( ) Run an insulated wire from solder lug C on the right potentiometer R12, to the bare wire GROUND BUS. Strip 1/8" insulation from each end and solder.
- ( ) Insert 10uF capacitor C6 as shown in Fig. 1. Bend the leads slightly outward to keep the capacitor in place.
- ( ) Run an insulated wire from solder lug B on the right potentiometer R12, to the negative (-) lead of C6. Strip 1/8" insulation from each end and solder.
- ( ) Insert 15K resistor R15 as indicated in Fig. 1. Solder one end to the positive (+) lead of capacitor C6. Trim both leads of C6 and R15.
- ( ) Insert 15K resistor R14 as shown in Fig. 1. Solder one end to the bare wire GROUND BUS. Trim the soldered lead of R14 only.
- ( ) Insert 1K resistor R18 as shown in Fig. 1. Solder one end to the bare wire GROUND BUS. Trim the soldered lead of R18 only.
- ( ) Bend one lead of R19 toward R18 and C7. Wrap one turn around R18 and the negative (-) lead of C7, then solder R19 to R18/C7. Trim the lead of R18 and R19 only.
- ( ) Insert 2N3904 transistor Q5 as shown in Fig. 1. Bend the base (B) lead toward R15/R16, the collector (C) lead toward R17, and the emitter (E) lead toward C7.
- ( ) Solder the base (B) lead of Q5 to resistors R15 and R16. Trim leads.
- ( ) Bend the negative (-) lead of C7 toward the emitter (E) lead of Q5 and solder. Trim leads.
- ( ) Solder the collector (C) of Q5 to R17 and trim Q5 lead only.
- ( ) Insert 1000uF capacitor C10 as shown in Fig. 1. Bend leads slightly outward to keep C10 in place.
- ( ) Wrap the negative (-) lead of C10 around the positive (+) pin of J3 but do not solder yet.
- ( ) Insert 0.47 Ohm resistor R21 as shown in Fig. 1. Bend leads slightly outward to keep R21 in place.

- ( ) Insert 0.47 Ohm resistor R20 as shown in Fig. 1. Bend leads slightly outward to keep R20 in place.
  - ( ) Run a bare wire between the positive (+) lead of C10, to R21 and R20, and then to R19. Solder the wire to C10, R21, R20, and R19. Trim all leads.
  - ( ) Insert 680 Ohm resistor R22 as shown in Fig. 1. Wrap one lead around the positive (+) pin of J3 and solder. Trim leads.
  - ( ) Insert 1N4148 diodes D3 and D4 as shown in Fig. 1. Twist the anode lead of D4 to the cathode lead of D3 and solder. Trim leads.
  - ( ) Wrap the cathode lead of D4 around R22 (one turn) and solder. Trim the soldered lead of D4 only.
  - ( ) Insert 100uF capacitor C9 as shown in Fig 1. Connect the negative (-) lead of C9 to R22/D4 and solder. Trim leads for D4 and C9 but do not trim R22 yet.
  - ( ) Wrap the anode lead of diode D3 to the positive (+) lead of C9 but do not solder yet.
  - ( ) Insert 2N3906 transistor Q6 as shown in Fig. 1. Connect the base (B) lead to R17 and solder. Trim leads.
  - ( ) Connect R17 to the emitter (E) lead of Q5 and solder. Trim the soldered lead of R17 only.
  - ( ) Connect the collector (C) lead of Q6 to the positive (+) lead of C9 and solder. Trim the soldered led of C9 only.
  - ( ) Insert 2N3904 transistor Q7 as shown in Fig. 1. Bend the base (B) lead of Q7 and the collector (C) lead of Q6 together and solder.
  - ( ) Connect R20 to the emitter (E) lead of Q7 and solder. Trim leads.
  - ( ) Using a short piece of bare wire, connect the emitter (E) lead of Q6 with the collector (C) lead of Q7. Solder the emitter (E) lead of Q6 but do not solder the collector (C) lead of Q7 yet.
  - ( ) Run an insulated wire between the positive (+) lead of J4 to the collector (C) lead of Q7. Strip 1/8" from each end. Solder the insulated wire to the collector (C) lead of Q7 and trim leads. Wrap the other end to the positive (+) lead of J4 and solder.
  - ( ) Insert 2N3906 transistor Q8 as shown in Fig. 1. Attach the unsoldered lead of R22 to the base (B) lead of Q8 and solder.
  - ( ) Connect R21 to the emitter (E) lead of Q8 and solder. Trim leads.
  - ( ) Run an insulated wire from the collector (C) lead of Q8 to the GROUND BUS. Trim 1/8" insulation from each end and solder.
  - ( ) Install heat sinks on Q3, Q4, Q7, and Q8.
- 

## **SPEAKER CONNECTIONS AND FUNCTIONAL TEST**

You have now completed the wiring of the stereo kit. Check all connections to ensure that there are no errors in construction. Connect permanent magnet speakers to the left and right channel output terminals J2 and J3. The terminals are marked plus (+) and minus (-) for the purpose of connecting both speakers exactly the same way. This is necessary to ensure that the speakers are in phase, that is both speakers will have identical cone motion when the stereo amplifier has a common input signal. With the speaker properly connected, you are now ready to connect the power source. Provided is a 9 volt battery clip for use with a standard 9 volt alkaline battery. Connect the red lead of the battery clip to the plus (+) terminal of J3 and the black lead to the minus (-) terminal of J3.

With the speakers and battery connected, you may run a quick functional test. Plug a 1/8" (3.5mm) stereo cable into J1. Turn the volume control R1, R12 fully clockwise and touch the stereo cable connector with your finger. A hum will be heard. In case of difficulty review the assembly instructions for proper construction and with a meter (if available) refer to the schematic for proper value of voltage to the transistors.

## **INPUT HOOKUP**

### **MUSIC PLAYER OR BLUETOOTH ADAPTOR**

Turn the volume control R1, R12 fully counter-clockwise and plug in a male-to-male 1/8" (3.5mm) cable between the music player and J1 of the amplifier. Start the music player

and slowly rotate the volume controls until sound is heard at the desired volume.

## AM/FM STEREO TUNER

Most consumer stereo component equipment uses phono connectors instead of tip-ring plugs. A stereo phono male to 1/8" stereo female adaptor will be needed to attach the amplifier. Turn the volume control R1, R12 fully counter-clockwise and plug in a male-to-male 1/8" (3.5mm) cable into J1 of the amplifier. Next connect the phono adaptor between the tuner and the 1/8" cable. Tune a station and slowly rotate the volume controls until sound is heard at the desired volume.

## TWEAKS AND HACKS

### HEAVY DUTY BATTERY SOURCE

A standard alkaline 9V battery will work for testing and low volume operation, however it will not last long with moderate to loud volume. To obtain longer portable operating time use a single PP9 9V 4500mAh battery (Amazon B000LMQ3SK) and battery clips (Mouser 534-262 and 534-269), or six alkaline batteries in a series battery holder. Below are the approximate amplifier run-times at full output power for various battery types.

CELL TYPE	RUN TIME
PP9	12 Hours
AA	6 Hours
C	22 Hours
D	45 Hours

### BATTERIES IN THE CASE

If component leads are kept short there should be just enough room for two 3-cell AA battery holders (Mouser 12BH331-GR) under the perfboard as shown in Fig. 4. Wire them in series and attached a small toggle switch (Mouser 10TA805) so that power can be turned on and off as needed. Attach double-sided tape to the back of the battery holders and install the batteries. Find the location that allows the perfboard to be fully seated, remove the tape backing, and stick the holder in position. A thin piece of cardboard can be placed over the battery holders to ensure the batteries do not touch component wiring.

Turn the switch on when running on battery power in the case. Turn the switch off when running on external battery or AC-DC power adapter.

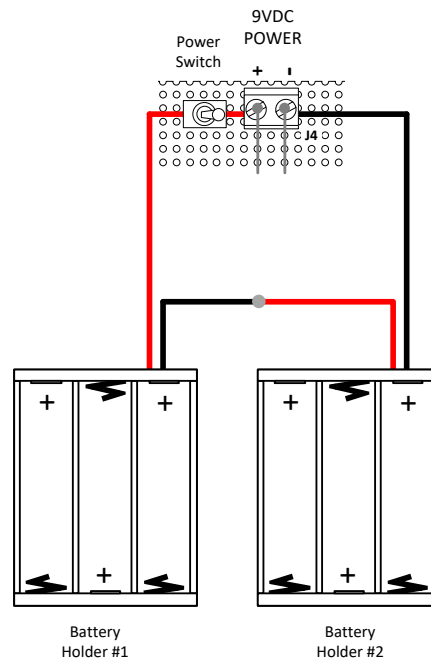


FIGURE 4

### BATTERY ELIMINATOR

An AC-DC power supply is recommended for non-portable use. 120V AC to DC 9V power supply 500mA or greater. A universal AC-DC power adapter with 9V and 12V settings, 1000mA output current, and various DC connector styles would be ideal. Replace the 2-position terminal block with a DC power connector (Mouser 490-PJ-050A).

### 12V BATTERY OPERATION

The amplifier can be modified to run with a 12V power source by replacing the following resistor values:

- R2, 82K Ohm 1% 1/4W resistor
- R8, 8.2K Ohm 1% 1/4W resistor
- R13, 82K Ohm 1% 1/4W resistor
- R19, 8.2K Ohm 1% 1/4W resistor

### OUTPUT OFFSET VOLTAGE ADJUSTMENT

To ensure that output power is evenly distributed between output transistors Q3/Q4 and Q7/Q8, the amplifier output voltage on the positive (+) pin of C5/C10 should be one half the power supply voltage. Due to component tolerances the output voltage can be as much as +/- 0.5V off. If you would like to fine tune the amplifier, replace R2 and R13 with 10-Turn 100K Ohm trimmer resistors as shown in Fig. 5. Start with the trimmers adjusted to their

maximum resistance before applying power. Attach speakers and power, then measure the voltage between the negative (-) power terminal and any lead of R9/R10 and R20/R21. Adjust R2/R13 until the voltage is one half the battery voltage.

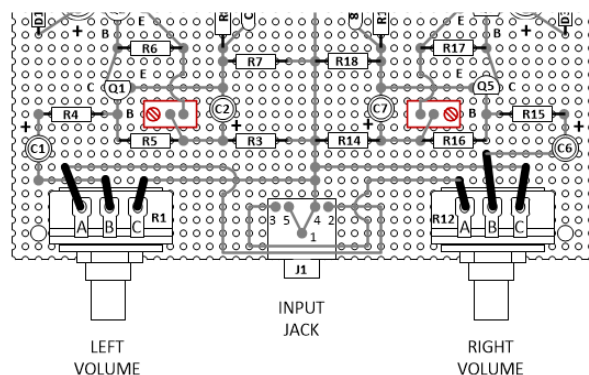


FIGURE 5

## STEREO RCA CONNECTORS

As shown in Fig. 6 the amplifier input connector can be changed to stereo RCA phono connectors (Mouser PJRAN2X1U01) instead of the 1/8" (3.5mm) stereo jack if desired. This allows most stereo component sources (CD players, tape decks, AM/FM tuners, etc.) to be connected to the amplifier without an adaptor cable.

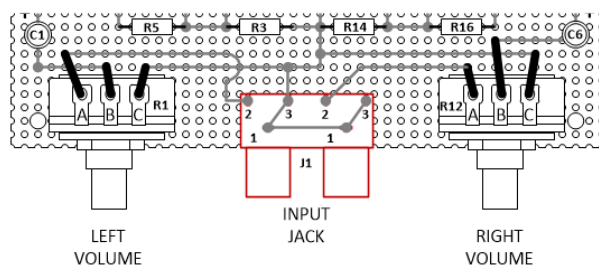


FIGURE 6

## LOWER PROFILE

The volume potentiometers R1 and R12 were oriented to make them easier to wire into the amplifier circuit. After soldering and testing, loosen the front potentiometer nuts and rotate each potentiometer so that the terminals face inward as shown. Then firmly retighten the potentiometer nuts. This reduces the amplifier height by 1/4". If more space is needed, the potentiometer mounting brackets can

be omitted and small PCB-mount potentiometers can be used. This will reduce the amplifier profile by 1" or more.

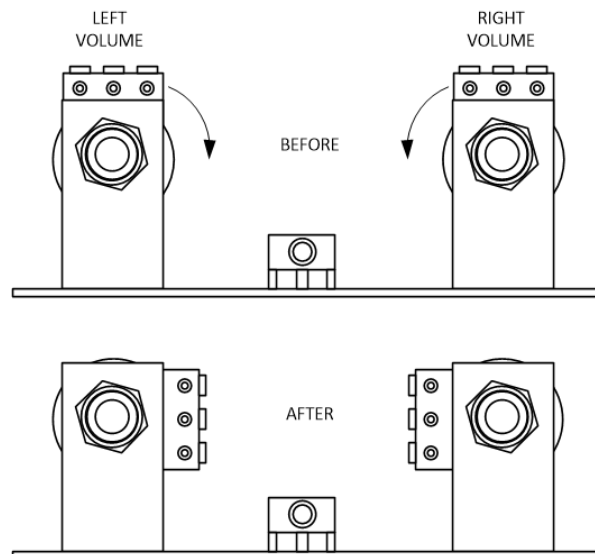


FIGURE 7

## LED POWER INDICATOR

To indicate that the amplifier is powered on, attach an LED and 560 Ohm 1% 1/4W current limit resistor as shown below.

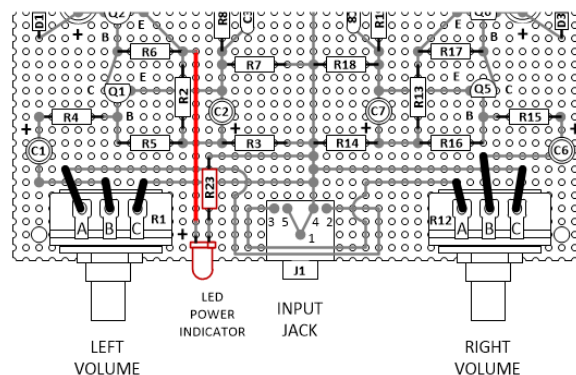


FIGURE 8

The above suggestions are only a few of the things that can be done to adapt the amplifier for different input and output requirements. There are many different changes and improvements that could be made limited only by your imagination.



SCHEMATIC

