Aikido

Aikido Mono 9-Pin PCB

USER GUIDE

Revision C

05/28/2008

GlassWare
AUDIO DESIGN

☛ Warning! ☚

This PCB is for use with a high-voltage power supply; thus, a real shock hazard exists. Once the power supply is attached, be cautious at all times. In fact, always assume that capacitors will have retained their charge even after the power supply is disconnected or shut down. If you are not an experienced electrical practitioner, before applying the B-plus voltage have someone who is experienced review your work. There are too few tube-loving solder slingers left; we cannot afford to lose any more. Additionally, the board's layout is more complex than previous revs due to all the jumpers, so more care must be exercised in following the instructions in this user guide. In other words, this PCB is not so much a plug-and-play endeavor, but a think-plug-and-play undertaking.

Rev. C Overview

Thank you for your purchase of the TCJ Aikido, 9-pin, revision-C, mono PCB. The boards are four inches by six inches, with five mounting holes. This FR-4 PCB is extra thick, 0.094 inches (inserting and pulling tubes from their sockets won't bend or break this board), double-sided, with plated-through 2oz copper traces, silk-screened on both sides. The boards are proudly—and expensively—made in the USA. Each PCB holds *one* complete Aikido line-stage (or headphone) amplifier. Thus for mono amplification, one board is needed; for stereo, two boards; and for five-channel, five boards.

Two Output-Stage Topologies The Rev. C board provides substantially more circuit configuration flexibility than the previous versions. The output stage can now be configured either as the classic Aikido line amplifier or as an Aikido headphone amplifier (with a White cathode-follower output stage).

More Output Tube Possibilities This board accepts many more output tubes, such as the 5687, 6900, 7044, 7119, 7370, 7892, and E182CC (and of course, the old standards, such as 6AQ8, 6BQ7, 6BS7, 6DJ8, 6CG7, 6GM8, 6H30, 6FQ7, 6N1P, 6N27P, 12AT7, 12AU7, 12BH7, 12DJ8, 5963, 5965, E80CC, ECC81, ECC82, ECC83, ECC86, ECC88, and ECC99).

New Heater-Connection Layout The heater arrangement has been redesigned so that many more input and output tube combinations are now possible. For example, the board can be used with 6.3V and 12.6V power supplies, as the heater jumpers allow tubes like the 12AX7 and 12BH7 to be wired as 6.3V tubes. In other words, it is now possible to use a 12AX7 as the input and a 6DJ8/6922 as the output tube (with a 6.3V heater power supply).

PCB Features

Redundant Solder Pads The board holds two sets of differently-spaced solder pads for each critical resistor, so that radial and axial resistors can easily be used (bulk-foil resistors and carbon-film resistors, for example). In addition, most capacitor locations find many redundant solder pads, so wildly differing-sized coupling capacitors can be placed neatly on the board, without excessively bending their leads.

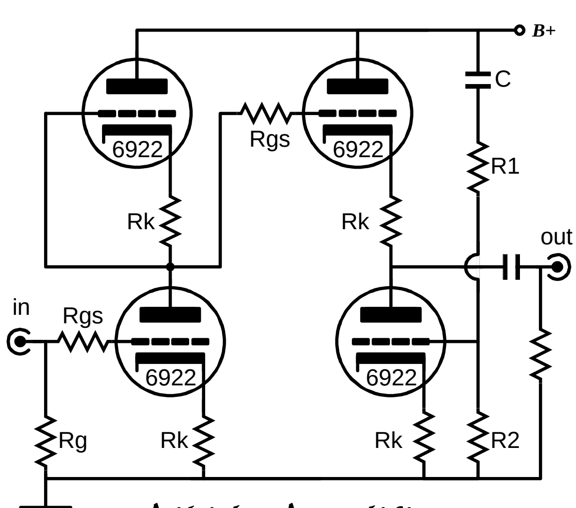
Dual Coupling Capacitors The PCB can hold two coupling capacitors, each finding its own 1M resistor to ground. Why? The idea here is that you can select (via a rotary switch) between coupling capacitors C1 or C2 or both capacitors in parallel. Why again? One coupling capacitor can be Teflon and the other oil or polypropylene or beeswax or wet-slug tantalum.... As they used to sing in a candy bar commercial: “Sometimes you feel like a nut; sometimes you don't.”

Each type of capacitor has its virtues and failings. So use the one that best suits the music; for example, one type of coupling capacitor for old Frank Sinatra recordings and the other for late Beethoven string quartets. Alternatively, the same flavor capacitor can fill both spots: one lower-valued capacitor setting a low-frequency cutoff of 80Hz for background or late night listening; the other higher-valued capacitor, 5Hz for full range listening. Or if you have found the perfect type of coupling capacitor, the two capacitors could be hardwired together on the PCB, one smaller one acting as a bypass capacitor for the lager coupling capacitor. On the other hand, each coupling capacitor can feed its own output, for example, one for low-frequency-limited satellites and one for subwoofers. Jumper J1 bridges the two outputs.

Introduction to the Aikido

The Aikido amplifier delivers the sonic goods. It offers low distortion, low output impedance, a great PSRR figure, and feedback-free amplification. The secret to its superb performance—in spite not using global feedback—lies in its internal symmetry, which balances imperfections with imperfections. As a result, the Aikido circuit works at least a magnitude better than the equivalent SRPP or grounded-cathode amplifier.

For example, the Aikido circuit produces far less distortion than comparable circuits by using the triode’s own nonlinearity against itself. The triode is not as linear as a resistor, so ideally, it should not see a linear load, but a corresponding, complementary, balancing non-linear load. An analogy is found in someone needing eyeglasses; if the eyes were perfect, then perfectly flat (perfectly linear) lenses would be needed, whereas imperfect eyes need counterbalancing lenses (non-linear lenses) to see straight. Now, loading a triode with the same triode—under the same cathode-to-plate voltage and idle current and with the same cathode resistor—works well to flatten the transfer curve out of the amplifier.



Aikido Amplifier

In this schematic, the triodes are so specified for example only. Although they would never fit on the printed circuit board (PCBs), 211 and 845 triodes could be used to make an Aikido amplifier. The circuit does not rely on 6922 triodes or any other specific triodes to work correctly. It’s the topology, not the tubes that make the Aikido special. (Far too many believe that a different triode equals a different topology; it doesn't. Making this mistake would be like thinking that the essential aspect of being a seeing-eye dog rested in being a Golden Lab.)

The Aikido circuit sidesteps power supply noise by incorporating the noise into its normal operation. The improved PSRR advantage is important, for it greatly unburdens the power-supply. With no tweaking or tube selecting, you should easily be able to get a -30dB PSRR figure (a conventional grounded-cathode amplifier with the same tubes and current draw yields only a -6dB PSRR); with some tweaking of resistor R15's value, -60dB or more is possible. Additionally, unless regulated power supplies are used for the plate and heater, these critical voltages will vary at the whim of the power company and your house's and neighbors' house's use, usually throwing the once fixed voltage relationships askew. Nevertheless, the Aikido amplifier will still function flawlessly, as it tracks these voltage changes symmetrically.

Remember, tubes are not yardsticks that never change, being more like car tires—they wear out. Just as a tire's weight and diameter decrease over time, so too the tube's conductance. So the fresh 6DJ8 is not the same as that same 6DJ8 after 2,000 hours of use. But as long as the two triodes age in the same way—which they are inclined to do, as they do the same amount of work and share the same materials and environment—the Aikido amplifier will always bias up correctly, splitting the B+ voltage between the triodes. Moreover, the Aikido amplifier does not make huge popping swings at start up, as the output does not start at the B+ and then swing down a hundred or so volts when the tube heats up, as it does in a ground-cathode amplifier.

Furthermore, the Aikido amplifier—like other Aikido techniques I have tried—seems to bypass much of the power supply squirrelliness, making the circuit sound as if it were attached to batteries or a well-regulated power supply. (This includes the sonic traces left by imperfect power supply capacitors.)

This circuit eliminates power-supply noise from the output, by injecting the same amount of PS noise at the top and bottom of the two-tube cathode follower circuit. The way it works is that the input stage (the first two triodes) define a voltage divider of 50%, so that 50% of the PS noise is presented to the CF's grid; at the same time the 100k resistors also define a voltage divider of 50%, so the bottom triode's grid also sees 50% of the PS noise. Since both of these signals are equal in amplitude and phase, they cancel each other out, as each triodes sees an identical increase in plate current (imagine two equally strong men in a tug of war contest).

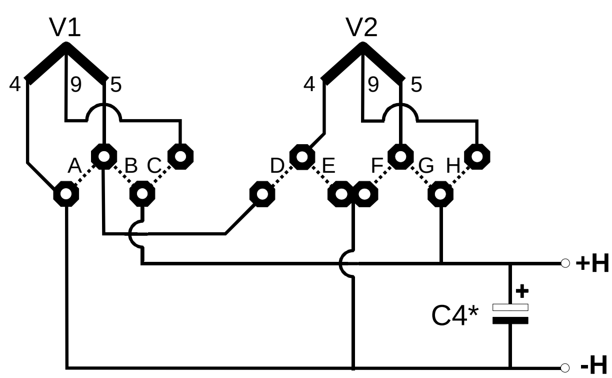
If the output connection is taken from the output cathode follower's cathode, then the balance will be broken. The same holds true if the cathode follower's cathode resistor is removed. (Besides, this resistor actually makes for a better sounding cathode follower, as it linearizes the cathode follower at the expense of a higher output impedance. Unfortunately, it should be removed and the bypass capacitor C3 should be used when driving low-impedance headphones, 32-ohms for example. When used as a line stage amplifier, No cathode resistor bypass capacitors should be used, as these capacitors are very much in the signal path and very few do not damage the sound, unless high quality capacitors are used.)

Heater Issues

Either 6.3V or 12.6V heater power supplies can be used for the tubes' heaters, so that 6.3V heater tubes (like the 6FQ7 and 6DJ8) or 12.6V tubes (like the 12AU7 or 5687) can be used. Tubes with 6.3V heater can be used with tubes with 12.6V heaters, if a 6.3V power supply is used, as tubes with 12.6V heaters, such as the 12AU7 and 5687 can have their heaters rewired for 6.3V power supplies. For example, a 6GC7 for the input tube and a 5687 for the output tube can be used, as long as the heater power supply is 6.3V.

(In theory, a 6.3V and a 12.6V tube could be used in series, with a 18.9V heater power supply, if the two tubes' heaters draw the same current, for example a 6922 and a 12BH7 [300mA], but this gets complicated. And 6.3V and 12.6V tubes can be used together with a 12.6V power supply, if all the tubes are wired for 6.3V use and then the two PCBs heater connections are placed in series; e-mail me for more details)

Rev. B Heater Jumper Wire Schedule



*Do not use capacitor C5 with AC heater power supply.

12.6V Heater Supply:

with V1 & V2 = **6.3V** tubes (in series),
for example, 6AQ8, 6CG7, 6DJ8, 6FQ7
install jumpers **D** & **G** only.

with V1 & V2 = **12.6V** tubes (in parallel),
for example, 12AT7, 12AX7, 12BH7, 5751, 6072
install jumpers **B**, **E**, & **G** only.

6.3V Heater Supply:
(V1 & V2 in parallel)

with V1 = **6.3V** tube, install jumper **B**.
for example, 6AQ8, 6BQ7, 6CG7, 6DJ8, 6FQ7

with V1 = **12.6V** tube, install jumpers **A** & **C**.
for example, 12AU7, 12AX7, 5751, 5963, 6072

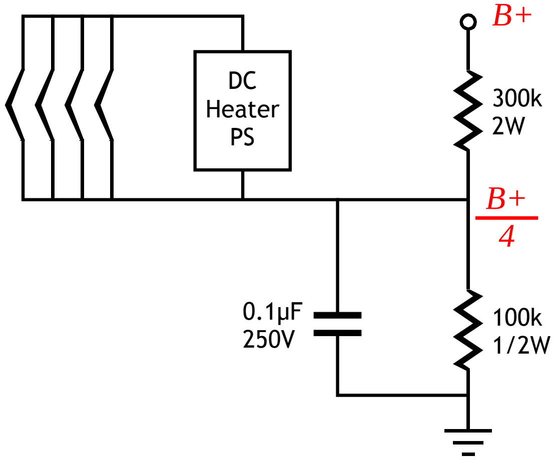
with V2 = **6.3V** tube, install jumper **E** & **G**.
for example 6AQ8, 6CG7, 6DJ8, 6FQ7, 6H30

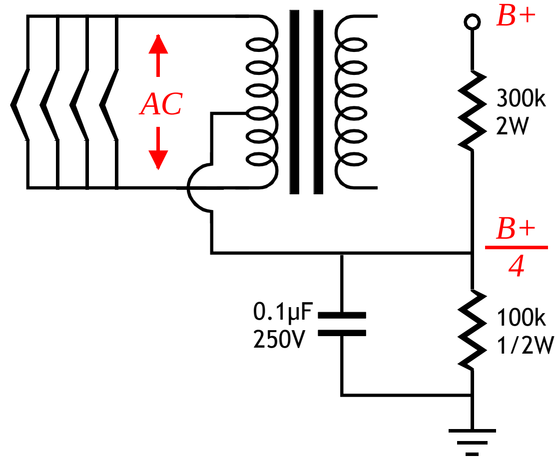
with V2 = **12.6V** tube, install jumpers **E**, **F**, & **H.**
for example12AU7, 12BH7, 5687, 7119, E182CC

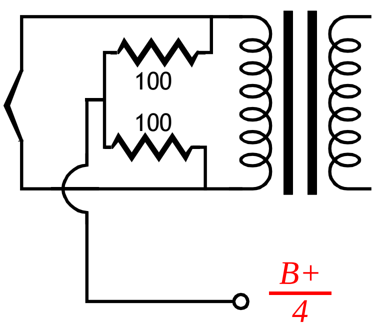
Although DC heater power supply certainly provides the lowest hum level and the clearest bass reproduction, the boards can be used with a DC or an AC heater power supply; if an AC power supply is used, then the heater reservoir capacitor, C4, must be left off the board or replaced by a 0.1µF film capacitor. Since in the Aikido topology, both triodes (in the same envelope) stand atop another, they cannot share the same heater-to-cathode voltage relationships.

The safest path is to reference the heater power supply to a voltage equal to one-fourth the B-plus voltage; for example, 75V, when using a 300V power supply. The ¼ B-plus voltage ensures that both top and bottom triodes see the same magnitude of heater-to-cathode voltage. The easiest way to set this voltage relationship up is the following circuits.

If the AC heater winding does not hold a center-tap, two 100-ohm resistors placed in series across the winding will create a pseudo center-tap that will work just as well as a true center-tap.





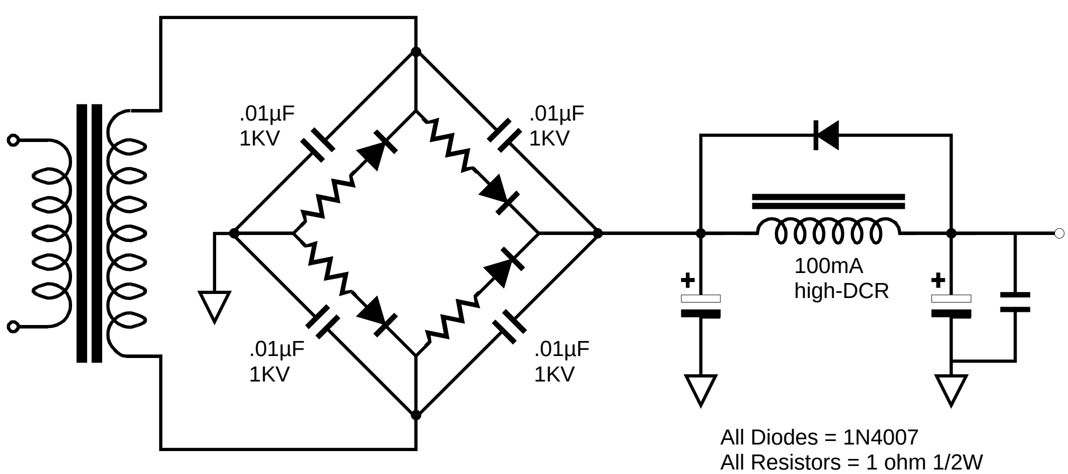


Alternatively, you might experiment with floating the heater power supply, by "grounding" the heater power supply via only a 0.1µF film or ceramic capacitor. The capacitor will charge up through the leakage current between heater and cathodes. Not only is this method cheap, it is often quite effective in reducing hum.

Power Supply

The power supply is external to the Aikido PCB and can be mounted in, or outside, the chassis that houses the PCB. The optimal power supply voltage depends on the tubes used. For example, 6GM8s (ECC86) can be used with a low 24V power supply, while 6FQ7s work better with a 250-300V B-plus voltage. The sky is <u>not</u> the limit here, as the heater-to-cathode voltage sets an upward limit of about 400V.

The genius of the Aikido circuit is found in both its low distortion and great PSRR figure. Nonetheless, a good power supply helps (there is a practical limit to how large a power-supply noise signal can be nulled). I recommend you use at least a solid, choke-filtered tube or fast-diode rectified power supply. If you insist on going the cheap route, try the circuit below, as it yields a lot of performance for little money. FRED rectifiers are expensive, but make an excellent upgrade to the lowly 1N4007.



Jumper J2 connects the PCB's ground to the chassis through the bottom rightmost mounting hole. If you wish to float the chassis, leave jumper J2 out; if you wish to capacitor couple the chassis to ground, replace jumper J2 with a small-valued, high-voltage capacitor (0.01 to 0.1µF, 250V to 600V). Warning: if rubber O-rings are used with PCB standoffs, then the ground connection to the chassis is not likely to be made.

Tube Selection

Unlike 99.9% of tube circuits, the Aikido amplifier defines a new topology without fixed part choices, not an old topology with specified part choices. In other words, an Aikido amplifier can be built in a nearly infinite number of ways. For example, a 12AX7 input tube will yield a gain close to 50 (mu/2), which would be suitable for a phono preamp or an SE amplifier's input stage; a 6FQ7 (6CG7) input tube will yield a gain near 10, which would be excellent for a line stage amplifier; the 6DJ8 or 6H30 in the output stage would deliver a low output impedance that could drive capacitance-laden cables or even high-impedance headphones.

In other words, the list of possible input tubes is a long one: 6AQ8, 6BC8, 6BK7, 6BQ7, 6BS7, 6DJ8, 6FQ7, 6GC7, 6H30, 6KN8, 6N1P, 12AT7, 12AU7, 12AV7, 12AX7, 12BH7, 12DJ8, 12FQ7, 5751, 5963, 5965, 6072, 6922, E80CC, E188CC, ECC88, ECC99. And as the output tube, all the tubes from the previous list would work, along with the following: 5687, 6900, 7044, 7119, 7370, 7892, and E182CC. When using a 5687-based tubes with a 9H basing as the output tube, use jumpers J3, J5, J7 only. When using a 6DJ8-, or 12AU7-based tubes as the output tube, use jumpers J4, J6, J8 only. **Tubes with a 9H base, such as the 5687 cannot be used as input tubes.**

There are only three stipulations: that the two triodes within the envelope be similar, that the tube conform to the 9A or 9AJ or 9H base pin-out, and that both input and output tubes can be configured to share the same heater voltage. For example, a 12DJ8 could not be used with a 6CG7, as the 12DJ8 cannot be configured to accept a 6.3V heater voltage.

Internal Shields

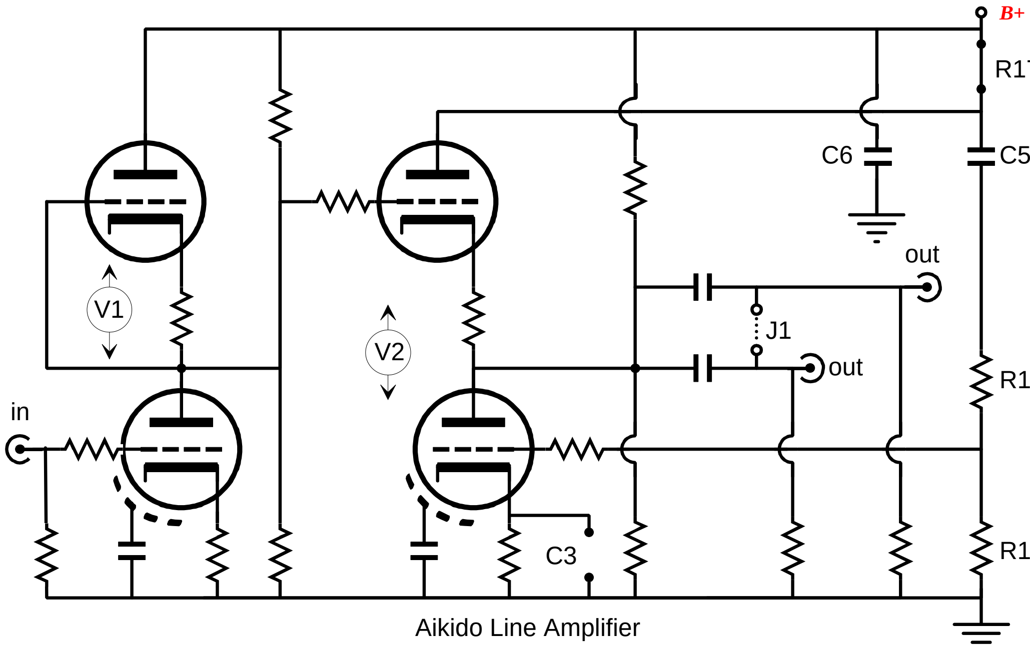
If the input or output triode's pin 9 attaches to an internal shield, as it does with the 6CG7 and 6DJ8, then capacitors, C7 and C8 can be replaced with a shorting wire, which will ground the shield. However, using the capacitors will also ground the shield (in AC terms) and allow using triodes whose pin 9 attaches to the center tap of its heater, such as the 12AU7. In other words, it best to use these capacitors instead of a shorting wire, as it adds flexibility and safety.

Cathode Resistor Values

The cathode resistor sets the idle current for the triode: the larger the value of the resistor, the less current. In general, high-mu triodes require high-valued cathode resistors (1-2K) and low-mu triodes require low-valued cathode resistors (100-1k). I recommend running the output tubes under a higher current than the input tubes, as much test confirms that the input stage's distortion contribution is amazingly indifferent to idle current, within reason of course.

Configuring the PCB as a Line Amplifier

The Aikido topology is perfect for line amplifier use, as it offers low distortion, low output impedance, and excellent power-supply noise rejection—all without a global feedback loop. The key points are not to use neither capacitor C3 nor resistor R17 and be sure to use resistor R15. For guidance on part values, look at the page that lists several line-amplifier design examples. R15's value equals R16 [(mu -2)/(mu + 2)].



Aikido Line Amplifier

Typical Part Values

() Parentheses denote recommended values

	6CG7 & 6DJ8 / 5687	6CG7 & 6CG7	12AU7 & 12AU7	12AU7 & 12BH7
B+ Voltage =	170V - 250V (200V)	200V - 300V (300V)	200V - 300V (250V)	200V - 300V (300V)
Heater Voltage =	6.3V	6.3V	12.6V	12.6V
R1,5,6,7,12,13 =	1M	1M	1M	1M
R2,4 =	270 - 1k (470)*	470 - 2k (870)*	470 - 2k (680)*	470 - 2k (1k)*
R3,9,10 =	100 - 1k (300)*	Same	Same	Same
R8,11 =	200 - 330 (200)*	270 - 680 (270)*	180 - 470 (200)*	200 - 470 (523)*
R15 =	87.5k	83.2k	80k	79.3k
R16 =	100k	Same	Same	Same
R17 =	0, Jumper	"	"	"

*High-quality resistors essential in this position
All resistors 1/2W or higher

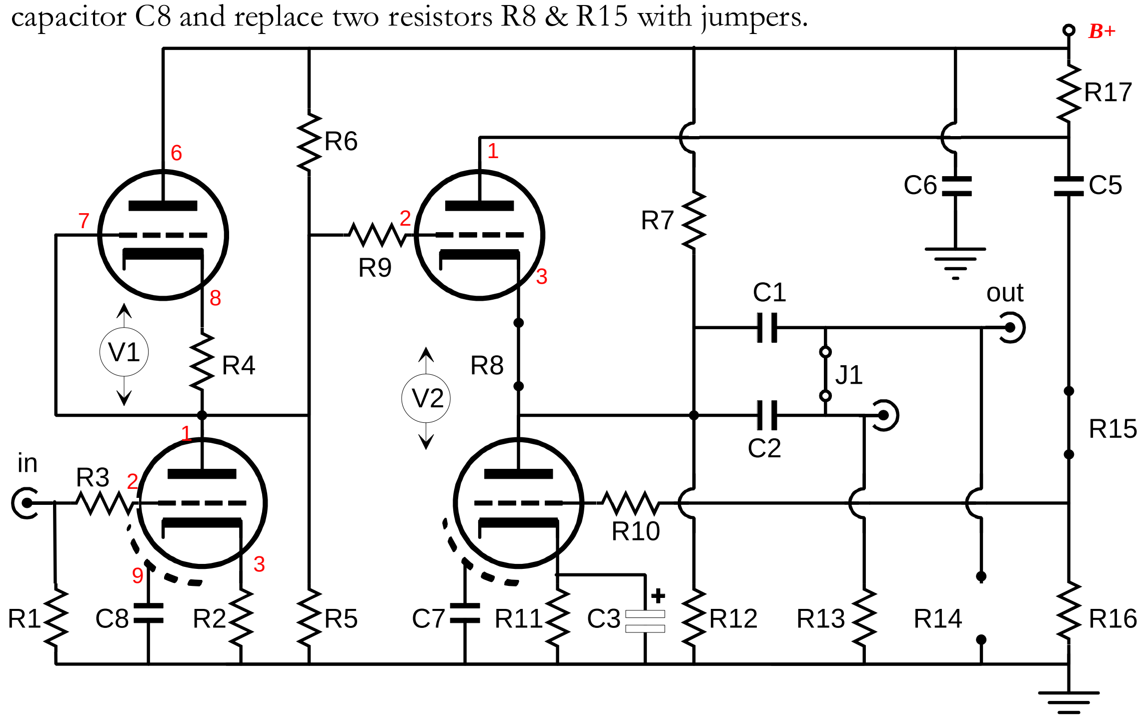
C1 =	0.1 - 4µF* Film	Same	Same	Same
C2 =	0.1 - 4µF* Oil	"	"	"
C5 =	1 - 10µF* Film or Oil	"	"	"
C6 =	.1µF* Film or Oil	"	"	"
C4 =	47µF - 1kµF, 10V	"	47µF - 1kµF, 16V	47µF - 1kµF, 16V
C3 =	470µF-10kµF, 10V	Same	Same	Same
C7 =	0.1µF 160V(optional)	Same	None	None
C8 =	0.1µF 160V(optional)	"	"	"

*Voltage rating must equal or exceed B+ voltage

(input) V1 =	6CG7, 6FQ7	6CG7, 6FQ7	12AU7, 5814, 5963, 6189, ECC82	12AU7, 5814, 5963, 6189, ECC82
(output) V2=	6DJ8, 6H30, 6922, 7308, ECC88, 5687, 6900, 7044, 7119, 7370, 7892, E182CC	6CG7, 6FQ7	12AU7, 5814, 5963 6189, ECC82	12BH7, ECC99

Configuring the PCB as a Headphone Amplifier

The standard Aikido is a thoroughly single-ended affair, nothing pulls while something else pushes. Unfortunately, wonderful as single-ended mode is sonically, it cannot provide the larger voltage and current swings that a push-pull output stage can. Single-ended stages can only deliver up to the idle current into a load, whereas class-A push-pull stages can deliver up to twice the idle current; and class-AB output stages can deliver many times the idle current. For a line stage, such big voltage and current swings are seldom required; headphones, on the other hand, do demand a lot more power; really, a 32-ohm load is brutally low impedance for any tube to drive. Fortunately, the PCB can be configured with an optimal White cathode-follower stage, which will both retain much of the Aikido's great PSRR and allow up to twice the idle current to be delivered into low-impedance loads. All that is required is to include resistor R17 and capacitor C8 and replace two resistors R8 & R15 with jumpers.



High transconductance output tubes are best for driving headphones, for example, the 6DJ8, 6H30, 12BH7, ECC99, 5687, 6900, 7044, 7119, 7370, 7892, and E182CC. A coupling capacitor of at least 33µF is required when driving 300-ohm headphones; 330µF for 32-ohm headphones. Capacitor C3 should be at least 470µF, with 1-2.2kµF working much better. Capacitor C3 can be bypassed by placing a small film capacitor across the leads of resistor R11.

In the optimal White cathode follower, the critical resistor is R17. This resistor is used to sense current variations through the top triode and the resulting anti-phase signal is relayed to the bottom triode. In other words, it sets the balance between top and bottom tubes and it establishes the excellent PSRR figure for the entire amplifier. A value that is too high or too low will compromise performance. Finding the correct value for resistor R17 is easy: $Ra = (rp + 2R_{load})/mu$, where rp equals the plate resistance and R_{load} equals the load impedance. From a quick inspection, we see that the lower the load impedance, the closer the formula comes to: $Ra = rp/mu$. On the other hand, when the load impedance is as much as 600 ohms and the rp as low as 2000 ohms, then the difference is fairly large.

Typical Part Values

() Parentheses denote recommended values

	6CG7 & 6DJ8 / 6H30 /5687	6CG7 & 6CG7	12AU7 & 12BH7 / ECC99
B+ Voltage =	170V - 250V (200V)	200V - 300V (300V)	200V - 300V (250V)
Heater Voltage =	6.3V	6.3V	12.6V
R1,5,6,7,12 =	1M	1M	1M
R2,4 =	270 - 1k (470)*	470 - 2k (1k)*	470 - 2k (1k)*
R3,9,10 =	100 - 1k (300)*	100 - 1k (300)*	100 - 1k (300)*
R8,11 =	200 - 330 (200)*	200 - 470 (330)*	200 - 470 (330)*
R13 =	10k	10k	10k
R15 =	0, Jumper	0, Jumper	0, Jumper
R16 =	300k - 1M (470k)	300k - 1M (470k)	300k - 1M (470k)
R17 =	100*	360*	127*

*High-quality resistors essential in this position
All resistors 1/2W or higher

C1 =	47µF* Film for 300-ohm HP 470µF* for 32-ohm HP	Same Not recommended	Same 470µF* for 32-ohm HP
C2 =	0.47µF* Film or oil	Same	Same
C5 =	1 - 10µF*	"	"
C6 =	0.047µF - 0.33µF* Film or oil	"	"
C3 =	10 - 1kµF, 10V Electrolytic	"	10 - 1kµF, 16V Electrolytic
C4 =	470µF-10kµF, 10V Electrolytic	Same	Same
C7 =	0.1µF 160V(optional)	Same	None
C8 =	0.1µF 160V(optional)	"	"

*voltage rating must equal or exceed B+ voltage

(input) V1 =	6CG7, 6FQ7	6CG7, 6FQ7	12AU7, 5814, 5963, 6189, ECC82
(output) V2=	6DJ8, 6H30, 6922, 7308, ECC88 5687, 6900, 7044, 7119, 7370, 7892, E182CC	6CG7, 6FQ7	12BH7, ECC99

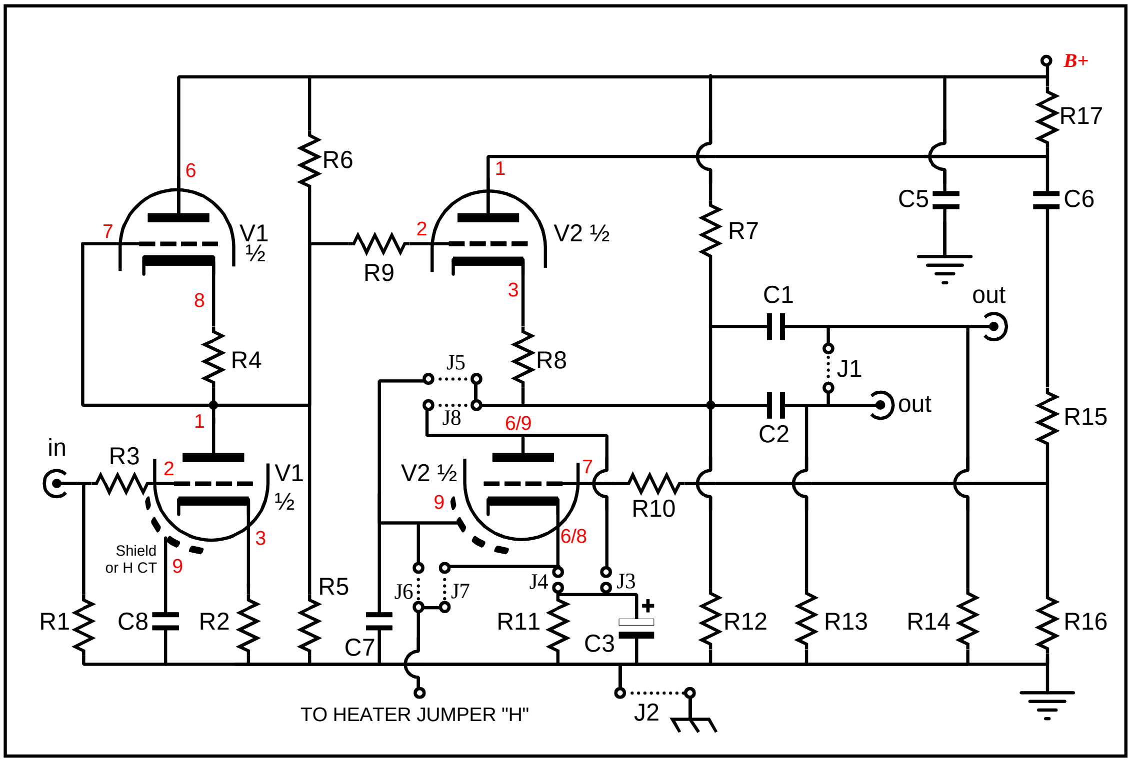
Assembly

Before soldering, be sure to clean both sides of the PCB with 90% isopropyl alcohol, wiping away all fingerprints. First, solder the shortest parts (usually the resistors) in place, then the next tallest parts, and then the next tallest... Make sure that both the solder and the part leads are shiny and not dull gray. Steel wool can restore luster and sheen by rubbing off oxidation. If some of the parts have gold-plated leads, remove the gold flash before soldering the part, as only a few molecules of gold will poison a solder joint, making it brittle; use sandpaper, steel wool, or a solder pot. NASA forbids any gold-contaminated solder joints; you should as well. (Yes, there are many quality parts with gold-flashed leads, but the use of gold is a marketing gimmick.)

Normally, such as when the PCB sits on the floor of its chassis, all the parts sit on the top side of the PCB (the top side is marked). If you wish to have the tubes protrude from holes on the top of the chassis (and to place the PCB within 1" of the top panel with the aid of standoffs), then all the other parts—*except* the tube sockets—can be placed on the PCB's backside; it is a double-sided board after all (be sure to observe the electrolytic capacitors' polarity and glue or tie-wrap heavy coupling capacitors to the PCB).

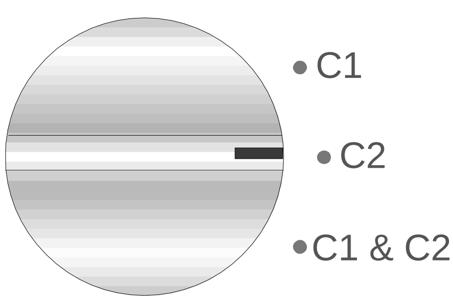
Let me know what you think

If you would like to see some new audio PCB or kit or recommend a change to an existing product or if you need help figuring out the heater jumper settings or cathode resistor values, drop me a line by e-mail to the address above (begin the subject line with either "Aikido" or "tube").

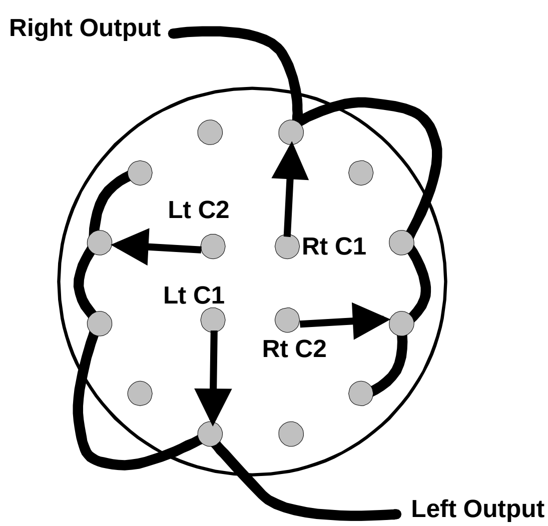


Mono 9-Pin Aikido PCB Rev. C Schematic

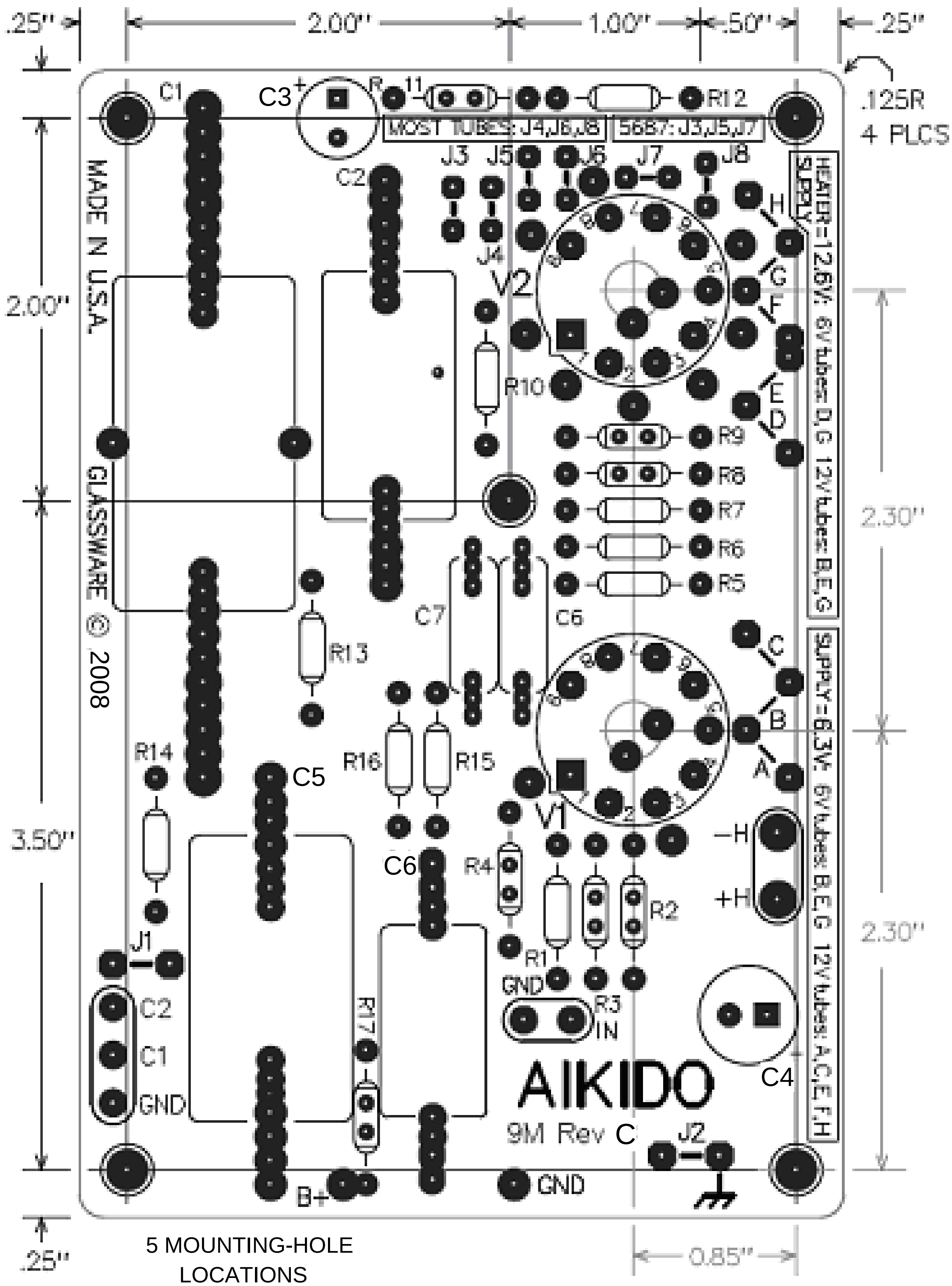
How do I wire up a rotary switch for switching between the two coupling capacitors? We need a four-pole, three-position switch and some hookup wire. All four coupling capacitors attach to the input contacts and the two channels of output can receive either coupling capacitors C1's or C2's or both capacitors' outputs. The drawing below shows the knob on the faceplate and the rotary switch from behind. (The switch is shown on the "C1 + C2" position.)



Switch Front



Switch Rear



Top Side PCB Mechanical Layout

Tube	mu	rp	Rk	Ik(mA)	B+	R15	R16	R17	Input Gain	Input Gain dBs	Output Gain	Output in dBs	Zo Line Amp	Zo HP Amp
6AQ8	57.0	9700	100	10.0	300	93220	100k	170	28.1	29.0	0.97	-0.24	248	85
6BK7	43.0	4600	200	10.0	300	91111	100k	107	21.2	26.5	0.97	-0.27	279	53
6BQ7	38.0	5900	191	10.0	300	90000	100k	155	18.7	25.5	0.96	-0.32	311	78
6BS8	36.0	5000	220	10.0	300	89474	100k	139	17.8	25.0	0.96	-0.33	321	69
6CG7	20.5	10200	583	3.0	150	82222	100k	498	10.0	20.0	0.93	-0.59	827	249
6CG7	21.1	8960	397	5.0	200	82684	100k	425	10.4	20.3	0.93	-0.59	657	212
6CG7	21.0	9250	626	5.0	250	82609	100k	440	10.3	20.2	0.94	-0.56	820	220
6CG7	20.8	9840	1000	4.5	300	82456	100k	473	10.1	20.1	0.94	-0.53	1063	237
6CG7	21.4	8370	470	7.3	300	82906	100k	391	10.5	20.4	0.94	-0.56	686	196
6CG7	21.9	7530	243	10.0	300	83264	100k	344	10.8	20.7	0.93	-0.60	489	172
6CG7	21.8	7680	352	10.0	350	83193	100k	352	10.7	20.6	0.94	-0.57	576	176
6DJ8	30.2	3670	182	5.0	100	87578	100k	122	15.0	23.5	0.96	-0.39	273	61
6DJ8	30.7	2870	124	10.0	150	87768	100k	93	15.2	23.7	0.96	-0.39	199	47
6DJ8	30.0	2960	205	10.0	200	87500	100k	99	14.9	23.4	0.96	-0.37	274	49
6DJ8	29.6	3060	291	10.0	250	87342	100k	103	14.6	23.3	0.96	-0.36	350	52
6DJ8	28.6	3980	673	5.0	250	86928	100k	139	14.0	22.9	0.96	-0.35	667	70
6DJ8	28.3	4080	845	5.0	300	86799	100k	144	13.8	22.8	0.96	-0.34	787	72
6DJ8	28.9	3400	481	8.0	300	87055	100k	118	14.2	23.0	0.96	-0.35	511	59
6FQ7	See 6CG7													
6GM8	14.0	3400	187	2.0	24	75000	100k	243	7.0	16.8	0.90	-0.90	357	121
6H30	15.4	1140	69	20.0	100	77011	100k	74	7.7	17.7	0.91	-0.80	127	37
6H30	15.9	1040	74	30.0	150	76471	100k	65	7.9	18.0	0.92	-0.75	124	33
6H30	15.4	1310	221	20.0	200	90431	100k	85	7.7	17.7	0.92	-0.68	267	43
6H30	15.4	1380	294	20.0	250	89474	100k	90	7.7	17.7	0.93	-0.66	330	45
6H30	15.0	1670	530	15.0	300	89189	100k	111	7.4	17.4	0.93	-0.65	528	56
6N1P	39.8	12200	328	3.0	200	89189	100k	307	19.4	25.8	0.96	-0.32	539	153
6N1P	36.0	9480	221	5.0	250	75000	100k	263	17.7	25.0	0.96	-0.36	422	132
6N1P	35.0	956	642	5.0	300	89189	100k	27	17.1	24.7	0.97	-0.25	569	14
6N27P	14.0	3400	187	2.0	24	75000	100k	243	7.0	16.8	0.90	-0.90	357	121
12AT7	60.0	15000	270	3.7	200	93548	100k	250	29.1	29.3	0.98	-0.21	457	125
12AU7	17.0	9560	427	2.5	100	78947	100k	562	8.4	18.4	0.92	-0.75	757	281
12AU7	16.6	9570	741	3.0	150	78495	100k	577	8.1	18.2	0.92	-0.71	959	288
12AU7	16.7	9130	768	4.0	200	78610	100k	547	8.2	18.2	0.92	-0.69	959	273
12AU7	17.9	7440	336	8.0	250	79899	100k	416	8.8	18.9	0.92	-0.71	601	208
12AU7	18.1	7120	328	10.0	300	80100	100k	393	8.9	19.0	0.92	-0.70	581	197
12AV7	37.0	6100	120	9.0	200	89744	100k	165	18.3	25.3	0.96	-0.36	258	82
12AV7	41.0	4800	56	18.0	300	90698	100k	117	20.4	26.2	0.96	-0.35	160	59
12AZ7	See 12AT7													
12AX7	100.0	62500	1100	1.0	300	96078	100k	625	42.6	32.6	0.99	-0.12	1238	313
12BH7	16.1	5480	340	4.0	100	77901	100k	340	8.0	18.0	0.92	-0.76	549	170
12BH7	15.7	6090	706	4.0	150	77401	100k	388	7.7	17.7	0.92	-0.71	826	194
12BH7	15.9	6140	787	5.0	200	77654	100k	386	7.8	17.8	0.92	-0.68	877	193
12BH7	17.4	4870	383	10.0	250	79381	100k	280	8.6	18.7	0.93	-0.67	541	140
12BH7	18.4	4300	267	15.0	300	80392	100k	234	9.1	19.2	0.93	-0.65	422	117
12BZ7	100.0	31800	560	2.0	300	96078	100k	318	48.5	33.7	0.98	-0.17	292	159
12DJ8	See 6DJ8													
12FQ7	See 6FQ7													
5687	18.1	1760	37	24.0	150	80100	100k	97	9.0	19.1	0.91	-0.78	119	49
5687	17.5	1970	132	20.0	200	79487	100k	113	8.7	18.8	0.92	-0.68	216	56
5687	17.4	2060	198	20.0	250	79381	100k	118	8.7	18.7	0.93	-0.65	276	59
5687	16.9	2440	397	15.0	300	78836	100k	144	8.4	18.5	0.93	-0.62	455	72
5751	70.0	58000	1250	0.8	200	94444	100k	829	30.5	29.7	0.98	-0.17	377	55
5963	21.0	6600	200	10.0	250	82609	100k	314	10.4	20.3	0.93	-0.63	433	157
5965	47.0	7250	220	8.2	300	91837	100k	154	23.1	27.3	0.97	-0.26	337	77
6072	44.0	25000	1250	2.0	300	91304	100k	568	20.3	26.2	0.97	-0.25	1272	284
7119	21.7	2390	324	15.0	300	83122	100k	110	10.7	20.6	0.95	-0.48	377	55
ECC81	See 12AT7													
ECC82	See 12AU7													
ECC83	See 12AX7													
ECC85	See 6AQ8													
ECC86	See 6GM8													
ECC88	See 6DJ8													

The table above lists many triodes suitable for the 9-pin-based Aikido amplifier PCB. The table lists the same tube under different B+ voltages and with different cathode resistor values. Two gains are listed: the first is the gain the tube realizes in the input position in the Aikido; the second is the gain of the same tube in the output stage.

To calculate the final gain multiply the two voltage gains together (or *add* the gain in dBs together). For example, given an Aikido line amplifier with a B+ voltage of 300V, and a 6CG7 input tube with cathode resistors of 1k, and a 6DJ8 output tube with cathode resistors of 481 ohms, the final voltage gain equals 10.1 from the 6CG7 against the 0.96 gain of the 6DJ8, with a product of 9.7. or, working with dB instead, 20.1dB plus -.35dB, for a total of 19.75dB. (Aren't decibels great?)

If you have additional data, send it in and I'll add to the list.