Amperex®

COMPLEMENTARY SYMMETRY

AUDIO TRANSISTORS

CIRCUITS and DATA

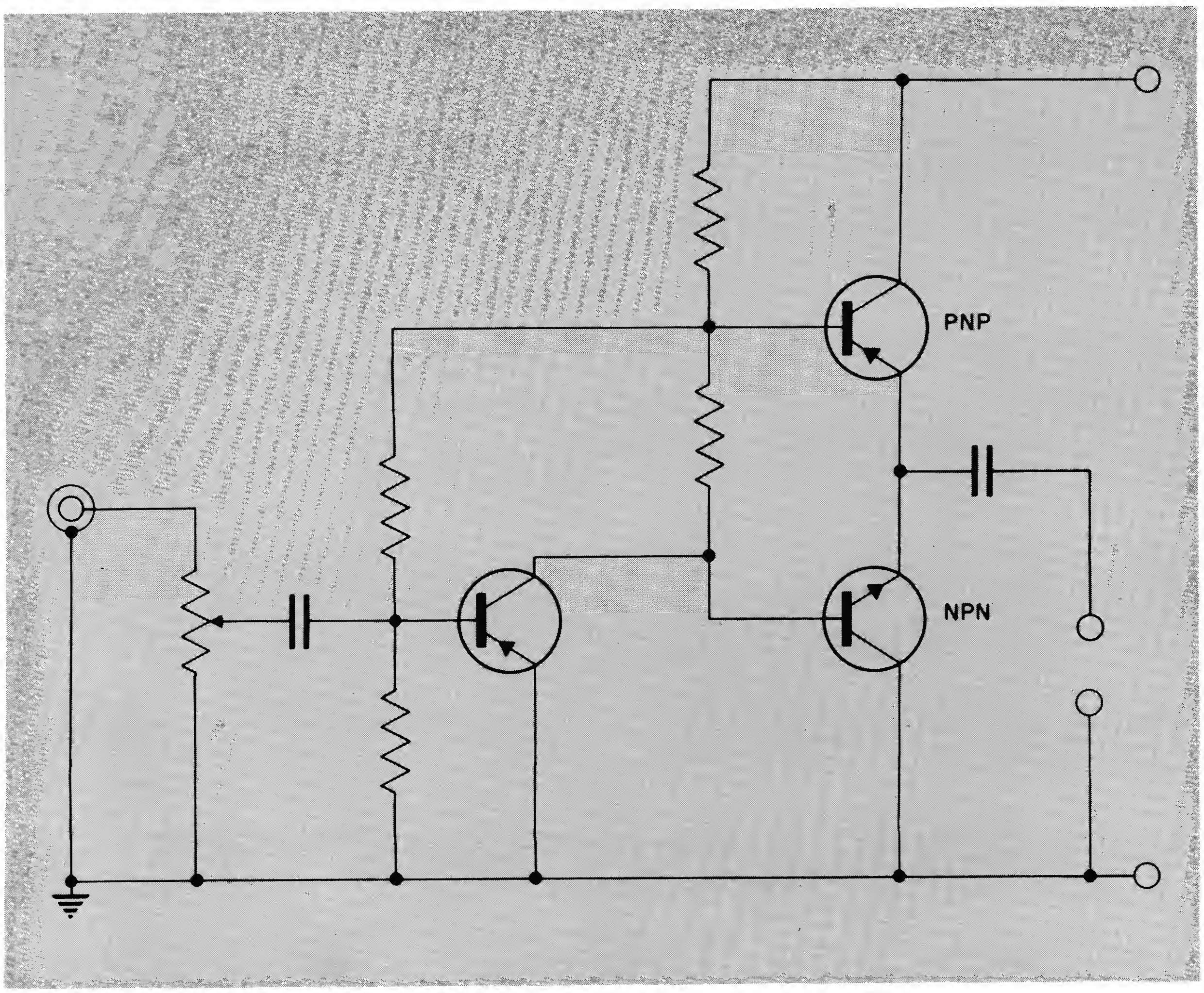
ELECTRON TUBES • SEMICONDUCTORS • COMPONENTS

AMPEREX ELECTRONIC CORPORATION

SEMICONDUCTOR AND RECEIVING TUBE DIVISION

SLATERSVILLE, RHODE ISLAND 02876 • 401/POplar 2-9000

Is complementary symmetry the only way to sell audio transistors today?

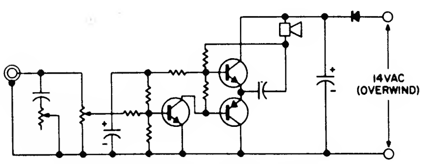


You bet it is!

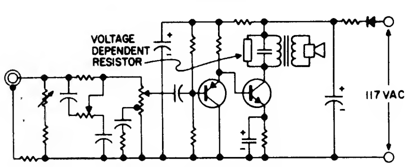
Complementary Symmetry is the ultimate in economical, reliable circuitry for audio applications up to 12 watts.

FOR PHONOS (1 to 5 WATTS)

Complementary Symmetry achieves enormous manufacturing savings with no sacrifice in reliability, by using transistors as they should be used—as low voltage, low impedence, low temperature devices for Class B push-pull, instead of high voltage, high impedance (Class A) with transformers and associated components and high temperatures.



THE AMPEREX WAY



THE OLD WAY

Low voltage eliminates need for bottom plates, interlocks, etc. **Low temperatures** mean longer, more reliable component life. **Simple mounting clip** eliminates need for expensive heat sinks, mica insulating washers and mounting hardware. **No output transformers or VDR's**... low output impedance of emitter follower output circuit obsoletes impedance-matching output transformer and related voltage dependent resistors.

Complementary Symmetry is not a new audio engineering approach! It has long been an audio designer's dream—a textbook approach! What is new, is that Amperex now provides the tools to make the textbook dream come true. We have the matched, paired transistors, dual heat-sinks, simplified circuits and application reports. Our applications department is at your service... and where required, complete breadboarded prototypes will be provided.

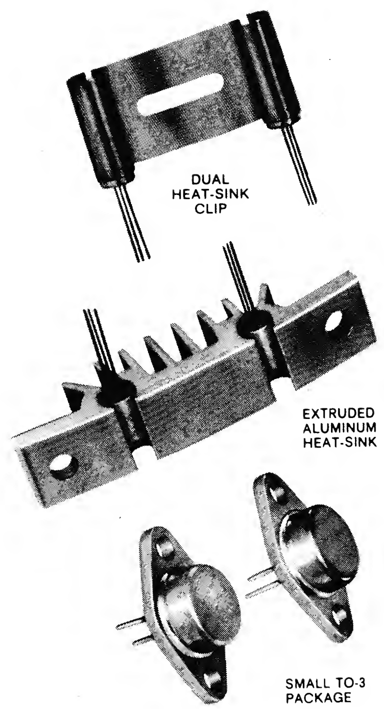
2N2707 matched pair 2N2430 (NPN) and 2N2706 (PNP) for power up to one watt for low cost phonos, amplifiers and radio; TO-1 cases in dual heat-sink clip.

2N4136 matched pair 2N2430 (NPN) and 2N2431 (PNP) for power up to 2.5 watts; TO-1 cases in dual heat-sink clip.

2N4107 matched pair 2N4105 (NPN) and 2N4106 (PNP) for power up to 7 watts; TO-1 cases in extruded aluminum heat-sink.

2N4079 matched pair 2N4077 (NPN) and 2N4078 (PNP) for power up to 12 watts; TO-3 cases.

FOR AUTO RADIO OUTPUTS
(5 watts at 13.6 volts)
THE NEW 2N4079 PAIR
IS IDEALLY SUITED



Amperex®

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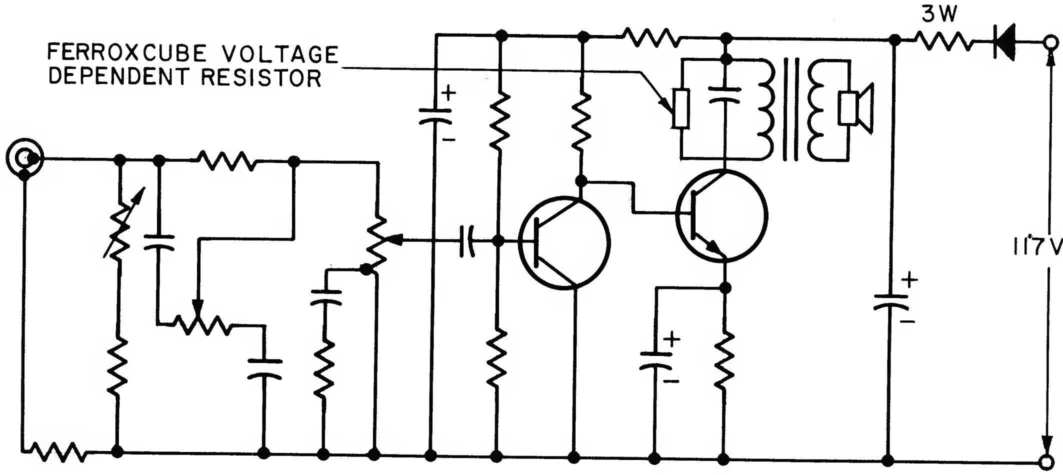
Types A-105 through A110	Type 2N2707
Types A-104, A115, A116	Type 2N4079
Type A-111	Type 2N4107
Type AD-158	Type 2N4136

AMPEREX AUDIO

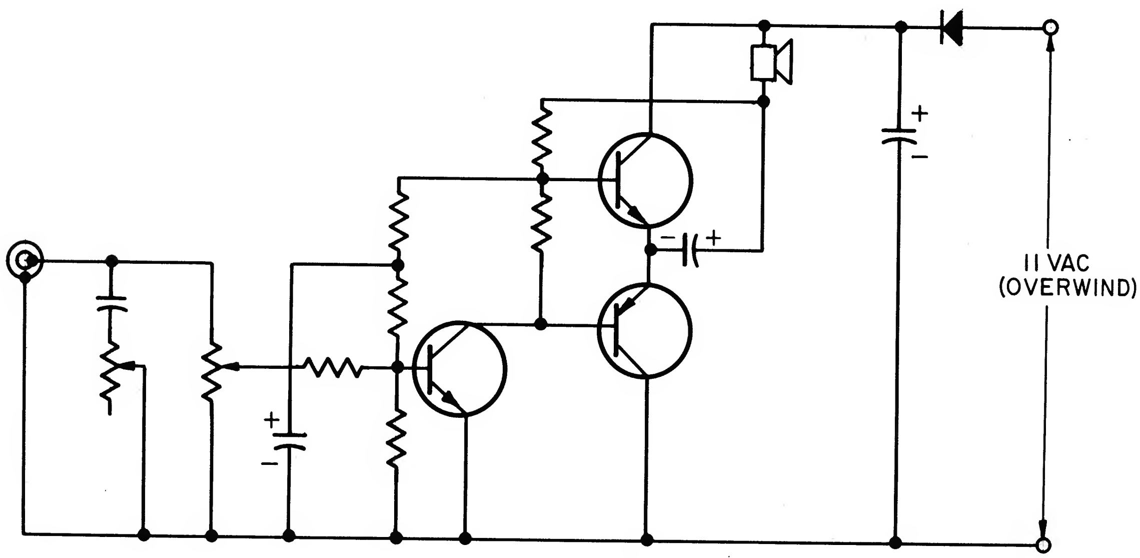
The basic Amperex philosophy for audio has been to use transistors as transistors should be used - as low voltage, low impedance, low temperature devices (in Class B push-pull), rather than Class A high voltage, high impedance (with output transformers) and high temperatures.

As an example, let us compare the Amperex 1 Watt Audio Amplifier with a competitive 1 Watt Audio Amplifier.

COMPARISON OF AMPEREX AND A COMPETITIVE ONE WATT PHONO



COMPETITOR'S WAY



AMPEREX'S WAY

AMPEREX ADVANTAGES:

1. Low voltage - provides substantial U. L. cost savings, since voltages lower than 30 do not require bottom plates, interlocks, etc.

2. Low temperatures - because of low idling currents in Class B configuration (total 10 ma at 14 volts = 140 milli-watts) compared to 2.5 to 4 watts in the Class A circuit. No heat means long component life - the real reason for using transistors in the first place! Switch from "hot" to "cools"!

3. Simple heat sink - since all electrodes of our TO-1 transistors are insulated from the case, and since there is relatively little heat generated, our dual clip holding the output pair can be conveniently riveted to a small tern-plate strip or control bracket eliminating the need for expensive, low thermal resistance heat sinks, mica insulating washers and mounting hardware.

4. No costly output transformers or VDR's - because of the low output impedance of our complementary output circuit, making impedance matching output transformers obsolete (similar to transistorized Hi-Fi equipment). Eliminating the output transformer eliminates the need for Voltage Dependent Resistors to protect the output transistor against transients, which can punch through and destroy the output device.

The use of a low voltage overwind (secondary winding) on a phono motor or clock motor provides complete isolation from the power line (as with a power transformer) for U.L. requirements and cost savings.

CLASS B "ACROSS THE BOARD"

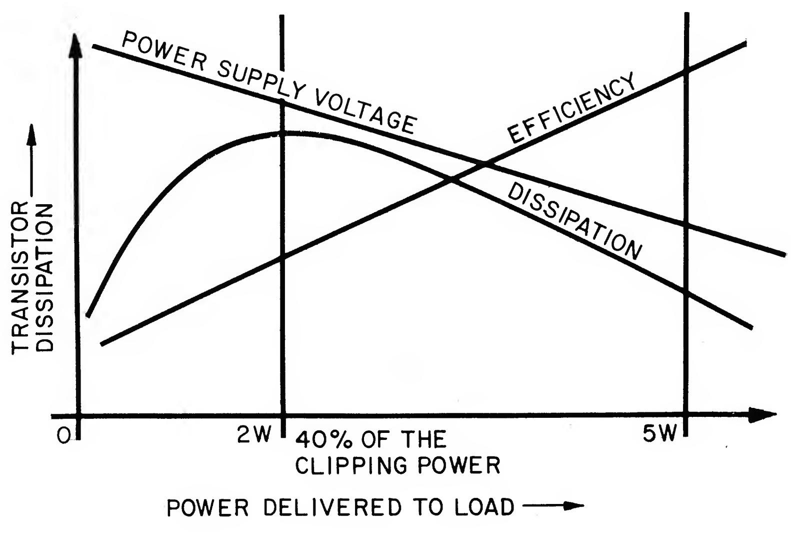
This basic Class B philosophy extends from the 1 watt level up through 50 watts RMS.

TRANSISTOR TYPE	POWER OUT	VOICE COIL	SUPPLY VOLTAGE
2N2707	1 W	8	10 V
2N4136	2-1/4 W	8	15 V
2N4107	5 W	8	20 V
2N4107 in HS-3	8 W	8	24 V
2N4079	12 W	8	28 V
For car radio application			
2N4079	5 W	3.2	13.6 V
QUASI-COMPLEMENTARY SYMMETRY			
2N4078 (MP)	12 W	8	26 V
2N2836/4241 (MP)	20 W	8	42 V
AD158 (Diffused Base) (MP)	25 W	8	46 V
		(MP) - Matched Pairs	
SINGLE-ENDED PUSH-PULL			
2N2431 (MP)	8 W	8	24 V
2N4078 (MP)	12 W	8	28 V
2N2836/4241 (MP)	25 W	8	42 V
AD158 (MP) Diffused Base	25 W	8	42 V
		(MP) - Matched Pairs	

Making 5 watts RMS with our TO-1 matched pairs is really no problem for engineers who are familiar with Class B transistor circuitry. Proper attention must be paid to power supply regulation and heat sink requirements. In Class B circuits it is more difficult to deliver 2 watts in a 5 watt amplifier than it is to deliver 5 watts! This paradox arises because of:

A.) The difference in circuit efficiency at 5 watts as compared to 2 watts and
B.) The rise in supply voltage because of power supply regulation at the 2 watt level.

If we were to plot transistor dissipation as a function of power delivered to the load, we would get the classical Class B curve as illustrated below:



You will notice that maximum dissipation within the transistor occurs at a power output level of approximately 40% of the maximum power output. At this point the circuit efficiency may be down to 50% (compared to 70% at the 10% distortion level). In addition, since we are drawing less current from the power supply, the voltage rises further increasing the transistor dissipation. If we were to drive the output transistors harder, the distortion would increase to the point where we would approach square wave output and the switching mode. At this point the power supply voltage would be at a minimum, the circuit could easily operate at 90% efficiency and the transistor dissipation would be at a minimum. Therefore, a 5 watt amplifier using TO-1's would be no problem, providing the supply is adequately regulated to limit the dissipation at the 2 watt level and adequate precautions are taken to provide thermal stability through the use of proper heat sinks, emitter resistors, and thermistor temperature compensation.

THERMAL STABILITY

Workable equations for Class B thermal stability just don't seem to exist, either they are too complex to be useable or they don't really accommodate all the possible variables. The position of the heat sink, its proximity to another source of heat, heat pocketing in the cabinet, etc., are some of the factors that are usually omitted from the calculations. These all affect the thermal resistance of the heat sink and are important in the final evaluation of overall thermal stability.

A PRACTICAL PROCEDURE FOR ASSURING THERMAL STABILITY IN CLASS B CIRCUITS

First off, be aware of those factors which affect thermal stability during the design phase and help yourself wherever you can. For example:

a. Use the largest emitter resistance the circuit can tolerate.

b. Use the stiffest bias network with the lowest possible D.C. resistance from the base back to the emitter. (Or base to base resistor in complementary circuits).

c. Resist the temptation to use the highest beta devices in the output stages. They may be easier to drive, but they aggravate the thermal stability problem by multiplying temperature sensitive leakage currents.

d. Choose devices with low leakage at high temperatures. Remember, beta and leakage increase with temperature.

e. Use the maximum heat sink available (consistent with the economics of the amplifier). Don't mount output transistors in heat pockets.

f. Don't use any more power supply than necessary to deliver the required power.

Once the design objectives (performance) have been achieved, the circuit should be checked out under worst case conditions as follows:

a. Install high beta-limit transistors.

b. Apply 10% higher line voltage.

c. Put set in oven at highest ambient temperature it may encounter in actual service in final enclosure. Bring out leads so that the collector current can be monitored.

d. Attach thermocouple to read transistor case temperature.

e. Record "no signal" idling current after it stabilizes at highest ambient temperature.

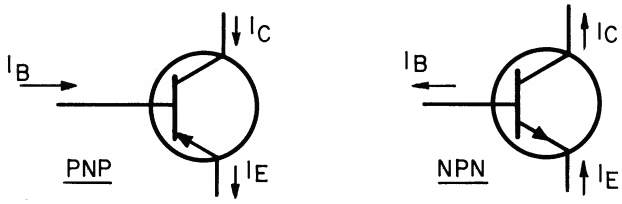
f. Drive amplifier to 40% of its rated output until the case temperature stabilizes and record temperature. Read Ic and Vce of output transistors and calculate dissipation. Using thermal resistance on data sheet and transistor case temperature, calculate junction temperature and check that it doesn't exceed maximum continuous junction temperature as specified on data sheet.

g. Remove drive signal and note the new "no signal" idling current drops back. This rate of drop is directly related to the thermal stability of the complete package. The faster it drops, the better the stability. A circuit that is not stable will exhibit a continuously rising current which will quickly go into thermal runaway. Using a sine wave signal at 40% of rated output subjects the amplifier to a transistor heat rise and dissipation that is approximately 20% greater than that which would normally be encountered with typical "music waveform" signals.

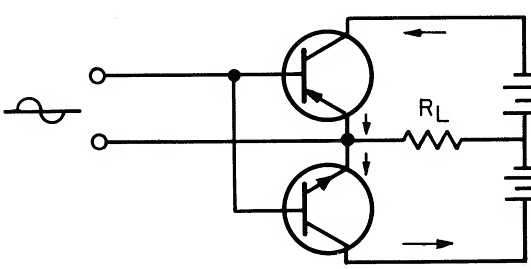
AMPEREX COMPLEMENTARY SYMMETRY DESIGNS

Due to the present copper shortage, production of audio amplifiers becomes a problem when audio output or driver transformers are used. With Amperex complementary symmetry designs both transformers are eliminated to achieve better performance, with lower cost and smaller size.

Basic complementary symmetry circuits use a PNP and a NPN transistor as the output pair. The electron current flow of the two transistors are opposite one another as indicated:



The two transistors are connected in series (as shown below) to permit a single ended stage to drive them as a Class B single-ended push-pull output. Each output transistor conducts during one half of each cycle.



A typical complementary symmetry (D.C. coupled) circuit is shown (PCA-1 - see diagram).

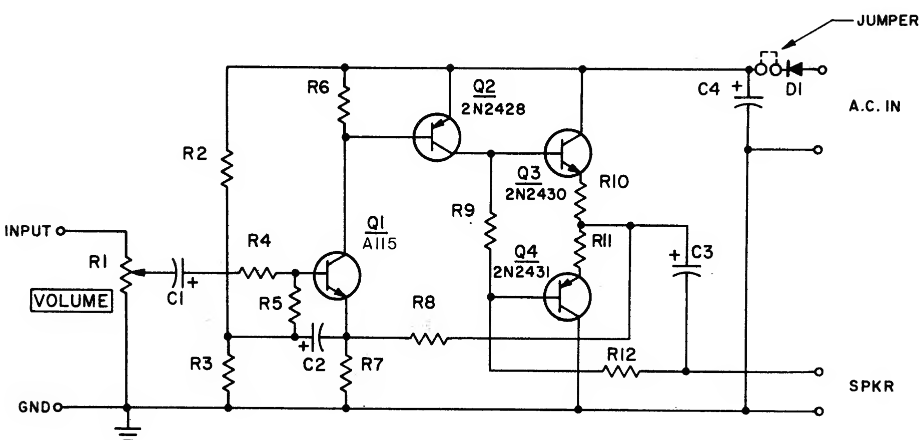
This circuit consists of a complementary push-pull output stage, a PNP driver stage and a NPN preamplifier stage. The features of the design are the economy effected in the number of components required, and the extremely good stability of the D.C. potential between Q3 and Q4, giving little variation of output with temperature changes.

The load is capacitively coupled to the emitters in the normal way, the bases being driven directly from the collector of Q2. The collector load of Q2 (R12) is returned to the emitters of the output transistors so that the output transistors are driven as a common emitter stage, instead of a common collector stage.

A small quiescent bias voltage is required for transistors operating in Class B push-pull. This is developed by the collector current of Q2 flowing through R9. R9 is very small compared to the R12.

The transistor Q1 serves a dual purpose. It acts as a preamplifier for A.C. signals and also as a D.C. difference amplifier. A voltage derived from the potential divider R2 and R3 is compared with the mid-point voltage between Q3 and Q4. The high D.C. loop gain of the circuit keeps the mid-point voltage between Q3 and Q4 constant, irrespective of spreads in the characteristics of the transistors Q1 and Q2 and the tolerance variations in the values of R5, R6, R12 and R4.

Negative feedback is taken via the resistor R8 from the output stage to the emitter of Q1. Bootstrapping is provided by capacitor C2 to maintain the high input impedance of Q1 while providing a low resistance bias source at its base.



SCHEMATIC OF PCA – I

AUDIO AMPLIFIER MEASUREMENTS

The power of audio amplifiers may be specified in a number of ways - - such as "RMS Power", "Music Power", etc. This quite often leads to confusion when prototypes are evaluated in the field. To help establish correlation, we will outline our measurement procedures along with some explanation of where problems can arise.

POWER

All Amperex amplifiers (prototypes or production units) are measured and specified as delivering a stated amount of continuous sine wave power into a specified load resistance at a specified level of distortion. In Class "B" power amplifiers, the drain on the power supply is a function of the power being delivered to the load - - as opposed to Class "A" amplifiers, where the drain is almost continuous. As a result, the power supply voltage under drive conditions depends upon the regulation (or impedance) of the power supply. Since the relationship for power is $\frac{(E)^2}{R}$ a slight change in E can result in substantial changes in power. To eliminate confusion, we have found it best to always specify the power with a regulated supply, and then where applicable include a IHFM power measurement as well, with a typical, practical supply.

The actual power measurements made in our application lab are made as follows:

a.) The power supply voltage is measured across the power supply filter capacitor with a 1% meter. (The power supply has 0.005% regulation and has 0.2 ohm output impedance at 20Kc.)

b.) A 1% (non-inductive) load resistance is used with dissipation capabilities of at least 5 times the power being measured.

c.) The AC (RMS) voltage is measured across this load resistor with a 1% VTVM (Ballantine 310-A) and the power is then calculated (rather than measured) on a watt-meter.

DISTORTION

Most of our amplifiers are rated for power output at 10% harmonic distortion at 1 Kc.

Our Hi-Fi designs are usually rated for power output at 1% at 1 Kc with additional measurements at 20 cps, 100cps, 10 Kc and 20 Kc. We also usually supply a "power-bandwidth" measurement which shows the power vs. frequency as a function of distortion.

SENSITIVITY & INPUT impedance are usually indicated as "worst-case" with the unlikely combination of low-limit transistors in all sockets.

TEMPERATURE RANGE

All designs are checked out under worst-case conditions which include:

a.) 10% high line voltage (with nominal equal to 115 Volts).

b.) Highest beta transistors.

c.) Ambients:

  1.) Thermistor stabilized designs to 60°C.

  2.) Non-thermistor stabilized designs to 40°C.

d.) Worst-case sine wave dissipation, approximately 40% of the sine wave clipping power.

(NOTE: This provides much more severe conditions than will be encountered in normal speech or music applications. If compromises are made to effect economies without affecting reliability in the actual application - - we will clearly indicate that these designs are "music-speech" stable, rather than "continuous sine with regulated supply" stable. Obviously, the consumer rarely listens to continuous sine wave signals, with regulated power supplies at high line voltages and high ambients simultaneously!)

SUMMARY OF ATTACHED APPLICATION CIRCUITS

1) 2 WATT COMPLEMENTARY AMPLIFIER — PCA-1-14*

This low cost circuit provides 2 watts output when driven from a crystal cartridge. It features very high stability and reliability along with a low operating temperature and compact size.

2) 1 WATT COMPLEMENTARY AMPLIFIER — PCA-1-9*

This circuit provides 1 watt output from a 9 volt battery or power supply. It features low battery drain along with a highly reliable and compact circuit without using any transformers.

3) LOW COST 1 WATT AMPLIFIER — PCA-2-14*

This low cost circuit provides one watt output with the least number of components. It uses TO-1 output transistors which are mounted with a heat sink clip provided by Amperex. Speaker is 12 or 16 ohms.

4) 4 WATT COMPLEMENTARY AMPLIFIER — PCA-3B-18-1*

This amplifier provides 4 watts output per channel from a crystal cartridge. It has bass and treble controls as well as loudness and balance controls. The amplifier is temperature stabilized by a thermistor and contains a low noise input transistor.

5) 2 WATT HIGH GAIN AMPLIFIER — PCA-4-14*

This amplifier provides 2 watts output when driven by a ceramic cartridge. This unit may also be used with a tuner or tape input. It has an optional tone control which provides a treble cut.

6) 1 WATT HIGH GAIN AMPLIFIER — PCA-4-9*

This circuit provides 1 watt output from a 9 volt battery with a ceramic cartridge input. It features a high gain circuit which allows an A.M. tuner to be used with it.

7) 2 WATT STEREO AMPLIFIER — PCA-5A-14*

This amplifier provides 2 watts output per channel when driven by a crystal cartridge. This is a stereo version of PCA-1-14 with a tone control added.

8) 10 WATT STEREO AMPLIFIER — PCA-6A-25

This amplifier provides 10 watts output per channel when driven by a ceramic cartridge. The circuit has complete bass, treble, volume and balance controls along with a low noise input. The circuit is temperature stabilized with a thermistor.

9) 10 WATT STEREO AMPLIFIER — PCA-6A-255CS

This amplifier is the same as the PCA-6A-25 with a separate preamp strip to allow mounting in compact phonographs.

10) 5 WATT AUTO RADIO CIRCUIT

This circuit uses the 2N4079 output transistors (small TO-3) 5 watts into a 3.2 ohm load. This circuit features a very stable D.C. bias circuit, (which is compensated for battery and temperature variations) as well as low battery drain.

11) 10 WATT COMPLEMENTARY SYMMETRY AMPLIFIER

This circuit uses the 2N4079 output transistors, which are in small TO-3 cases (diamond shape). The frequency response of this circuit is from 25Hz to 65KHz at -3db, with the low frequency response limited by the values of the electrolytic capacitors.

12) 8 WATT GUITAR AMPLIFIER

This complete amplifier circuit features a transformerless output circuit using a complementary design. This provides excellent frequency response (20Hz - 30KHz). The amplifier has full bass and treble controls along with tremolo rate and intensity controls. The tremolo circuit used allows 100% modulation with very low distortion.

13) 20 WATT HI-FI AMPLIFIER

This circuit features very low distortion together with wide frequency response and high power output. (Typically 1% distortion 100Hz to 10KHz at 20 watts). The output transistors, along with their complementary drivers are available in a matched package. This matching provides the four transistors with a gain variation of only ±1 db from set to set! The output transistors are diffused germanium with an F_t of 20 MHz and are matched to each other for beta at 300 ma and 3 amps. The 4 transistor kit is available at less than the cost of competitive output pairs.

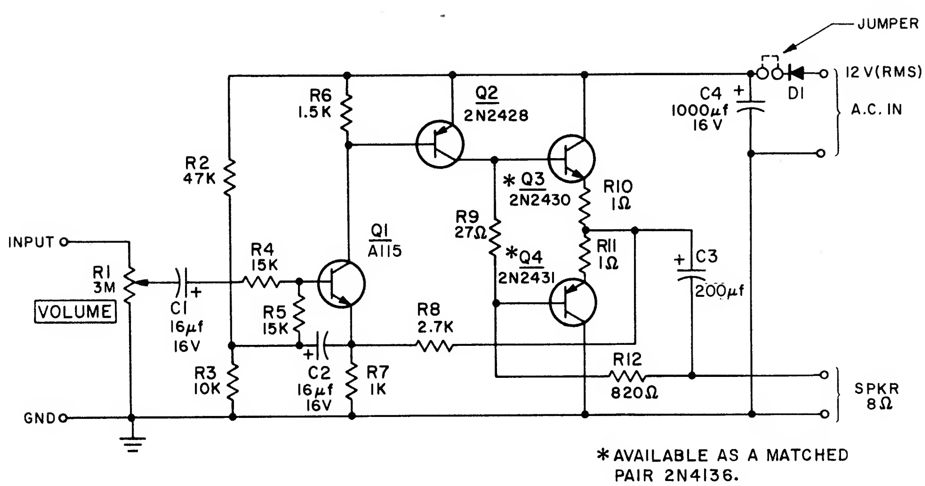
*Available from Amperex as complete assembly.

CIRCUITS AND DATA

(PAGES 8 - 28)

GENERAL SPECIFICATION FOR PCA-1-14

Supply Voltage:	14V DC (Regulated for measurement purposes)
Load Impedance:	8-16 ohms
Input Impedance:	600K ohms avg 220K ohms min
Input Sensitivity for 1.9W:	1.5V avg
Power Output:	1.9W @ 10% distortion @ 1 KHz @ 8 ohms
	1.3W @ 10% distortion @ 1 KHz @ 16 ohms
Idle Current:	15 ma
Maximum Current for 1.9W:	210 ma
Frequency Response:	@ 1W @ 8 ohms
	100 Hz - 40 KHz @ -3 db
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms
	0.1W 0.25%
	0.5W 0.55%
	1.0W 0.95%
	1.5W 2.2%
	2.0W 12.0%

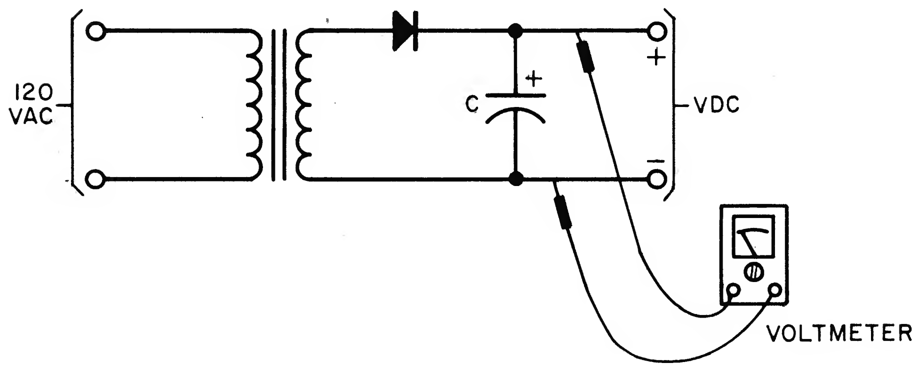


SCHEMATIC OF PCA-1-14

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-1-14

Circuit Diagram:	Half Wave
Filter Capacitor:	C = 1000 uf
Silicon Diodes:	use 300 ma min
DC Voltage Output:	15V max @ 10 ma 13V min @ 200 ma

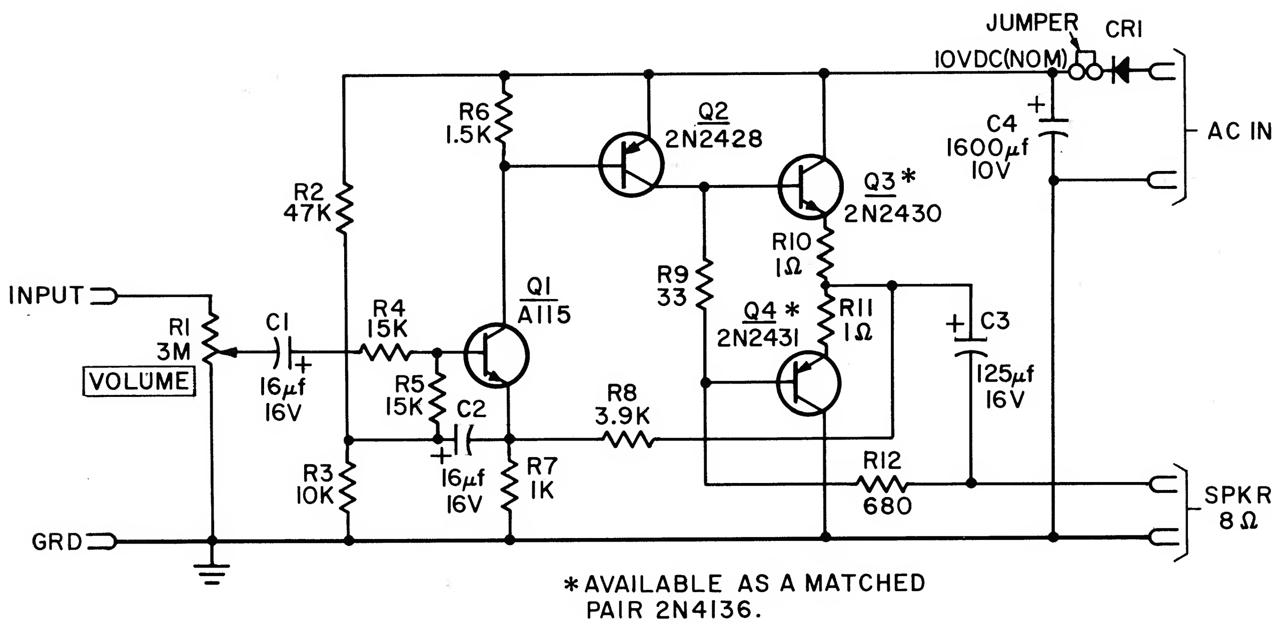
This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.



GENERAL SPECIFICATION FOR PCA-1-9

Supply Voltage:	9V DC (Regulated for measurement purposes)
Load Impedance:	8-16 ohms
Input Impedance:	600K ohms avg 220K ohms min
Input Sensitivity for 1.0W:	0.7V avg 0.9V max
Power Output:	1.0W @ 10% distortion @ 1 KHz @ 8 ohms
	0.7W @ 10% distortion @ 1 KHz @ 16 ohms
Idle Current:	13 ma
Maximum Current for 1.0W:	150 ma
Frequency Response:	@ 0.5W @ 8 ohms
	100 Hz - 50 KHz @ -3 db
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms

0.1W	0.2%
0.25W	0.4%
0.50W	0.72%
0.75W	1.3%
1.0W	10.0%

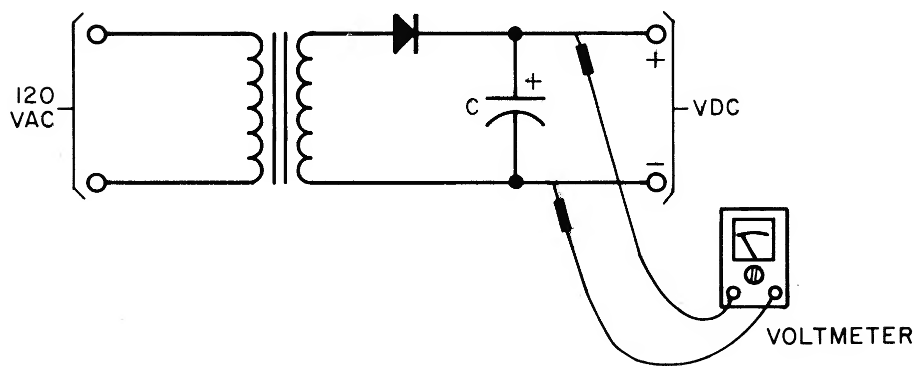


PCA-1-9

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-1-9

Circuit Diagram:	Half Wave
Filter Capacitor:	C = 1000 uf
Silicon Diodes:	use 250 ma min
DC Voltage Output:	10.5V max @ 10 ma 9.0V min @ 150 ma

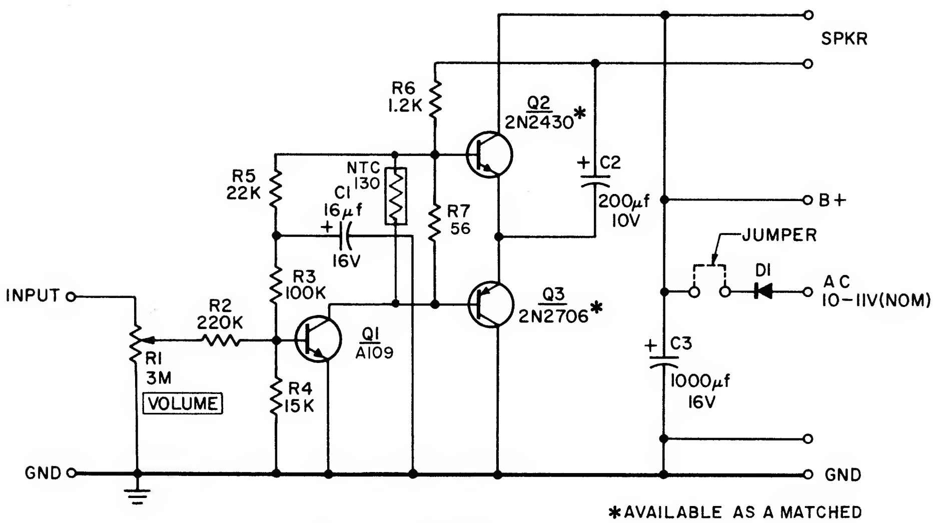
This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.



GENERAL SPECIFICATION FOR PCA-2-14

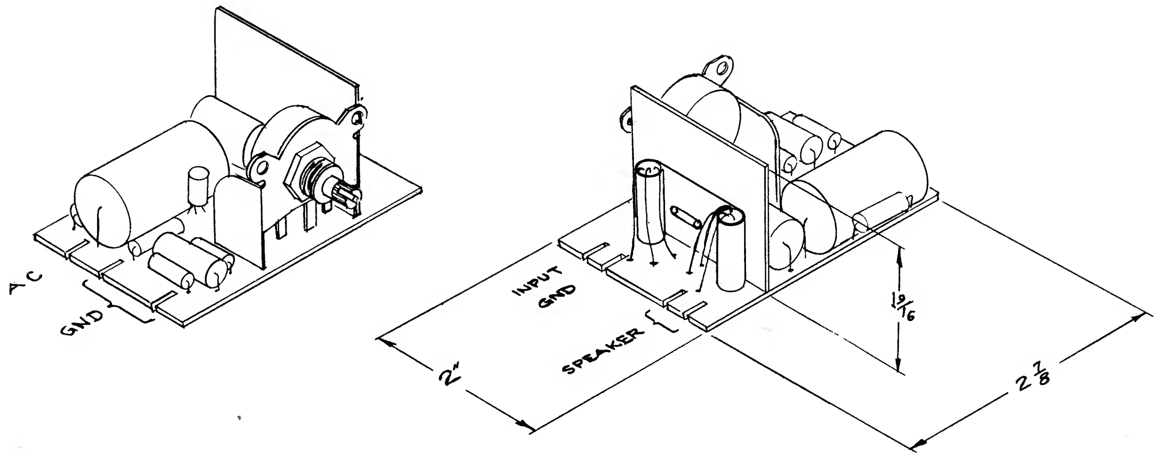
Supply Voltage:	14V DC (Regulated for measurement purposes)
Load Impedance:	12-16 ohms
Input Impedance:	220K ohms min
Input Sensitivity for 1W:	2.8V avg 3.0V max
Power Output:	0.9W @ 10% distortion @ 1 KHz @ 12 ohms
	0.8W @ 10% distortion @ 1 KHz @ 16 ohms
Idle Current:	8-12 ma
Maximum Current for 1W:	120 ma
Frequency Response:	@ 0.5W @ 16 ohms
	80 Hz - 25 KHz @ -3 db
Power vs Total Harmonic Distortion:	@ 1 KHz @ 16 ohms

0.1W	3.0%
0.25W	5.0%
0.50W	7.0%
0.75W	9.0%
1.0W	12.0%



SCHEMATIC OF PCA-2-14

*AVAILABLE AS A MATCHED PAIR 2N2707.

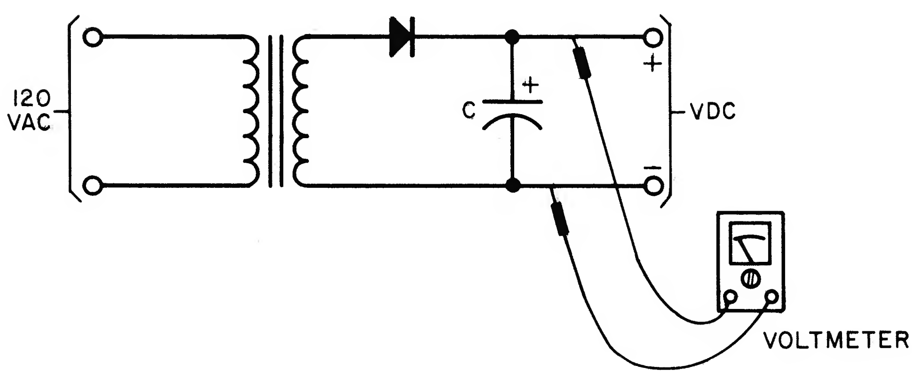


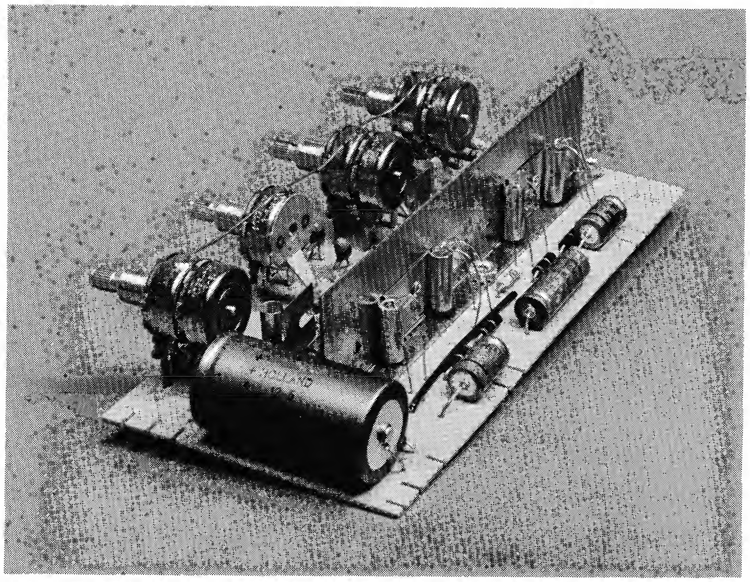
PCA-2-14

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-2-14

Circuit Diagram:	Half Wave
Filter Capacitor:	C = 1000 uf
Silicon Diodes:	200 ma min
DC Voltage Output:	14.5V max @ 8 ma 12.0V min @ 120 ma

This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.





GENERAL SPECIFICATION FOR PCA-3B-18-1

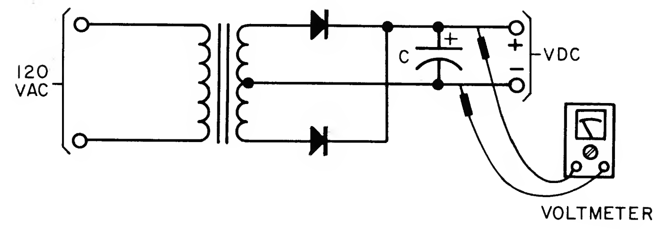
Supply Voltage:	18V DC (Regulated for measurement purposes)
Load Impedance:	8 ohms
Input Impedance:	1 megohm avg 300K ohms min
Input Sensitivity for 4.5W:	1.6 volts avg
Power Output:	4.5W @ 10% distortion @ 1 KHz @ 8 ohms
Idle Current:	12 ma
Maximum Current for 4.5W:	320 ma
Frequency Response:	@ 1W @ 8 ohms 45 Hz - 20 KHz @ -3 db
Tone Controls:	Treble + 6 db -15 db @ 10 KHz Base + 7 db - 12 db @ 100 Hz
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms

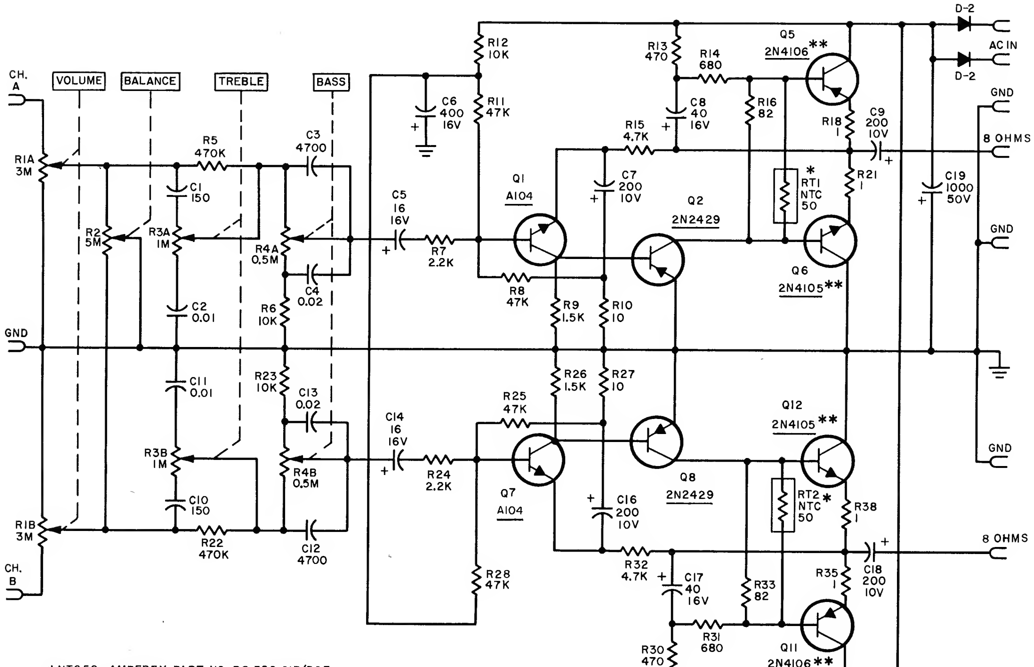
0.1W	1.5%
0.5W	2.0%
1.0W	2.5%
2.0W	3.0%
3.0W	3.5%
4.0W	6.0%
5.0W	15.0%

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-3B-18-1

Circuit Diagram:	Full Wave Center Tapped Secondary
Filter Capacitor:	C = 1000 uf
Silicon Diodes:	500 ma min
DC Voltage Output:	19.5V max @ 40 ma 16.5V min @ 700 ma

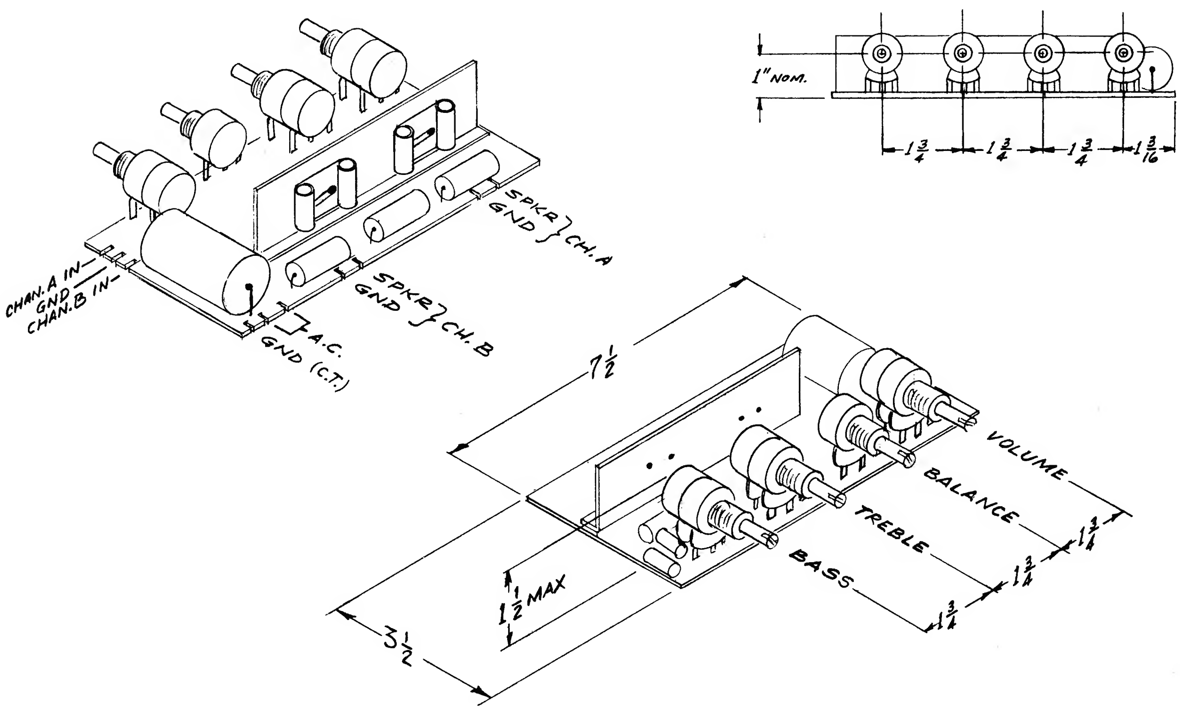
This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.



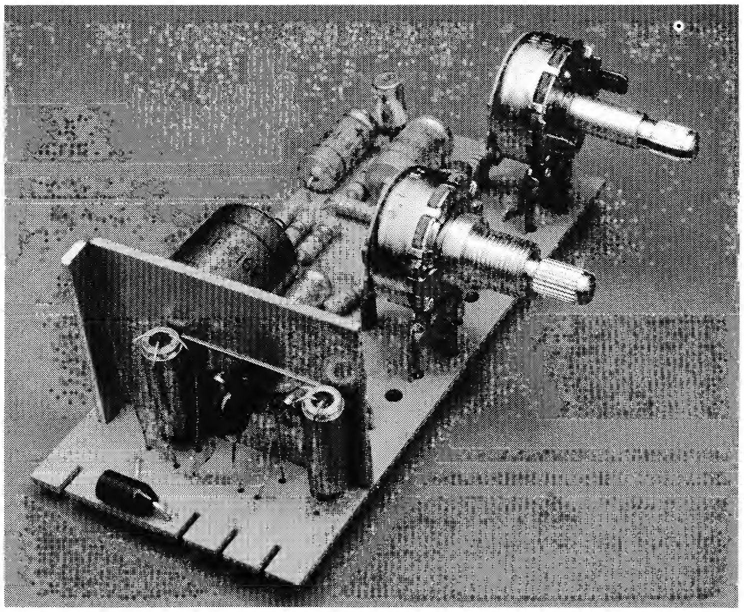


*NTC50—AMPEREX PART NO. B8 320 01P/50E
**2N4105 & 2N4106 ARE AVAILABLE AS A MATCHED PAIR (2N4107).
***PCA-3B-18-1 IS LATER VERSION OF PCA-3B-18

PCA-3B-18-1



OUTLINE DWG PCA-3B-18-1



GENERAL SPECIFICATION FOR PCA-4-14

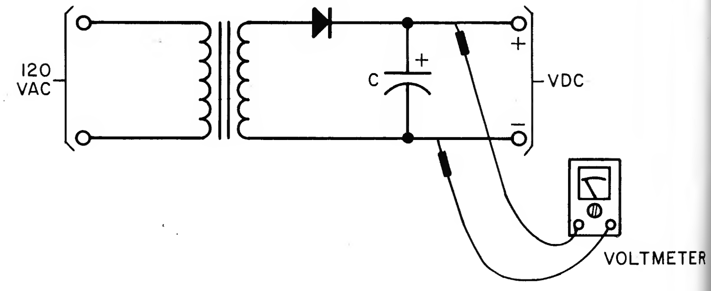
Supply Voltage:	14V DC (Regulated for measurement purposes)
Load Impedance:	8-16 ohms
Input Impedance:	25K ohms avg 20K ohms min
Input Sensitivity for 1.9W:	0.040V avg 0.045V max
Power Output:	1.9W @ 10% distortion @ 1 KHz @ 8 ohms
	1.0W @ 10% distortion @ 1 KHz @ 16 ohms
Idle Current:	14 ma
Maximum Current for 1.9W:	240 ma
Frequency Response:	@ 1W @ 8 ohms
	40 HZ - 18 KHz @ -3db
Tone Control: (optional)	Treble + 0 db -12 db @ 10 KHz
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms

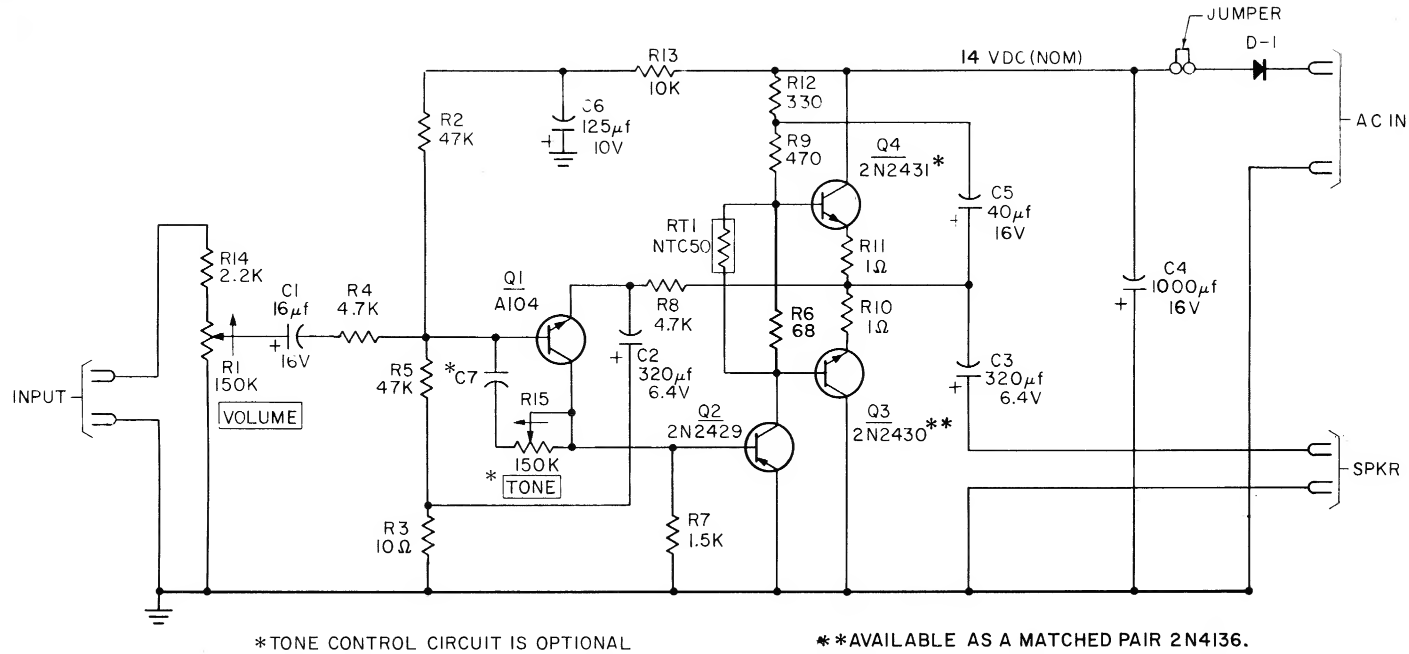
0.1W	1.0%
0.5W	2.7%
1.0W	3.5%
1.5W	5.2%
2.0W	12.0%

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-4-14

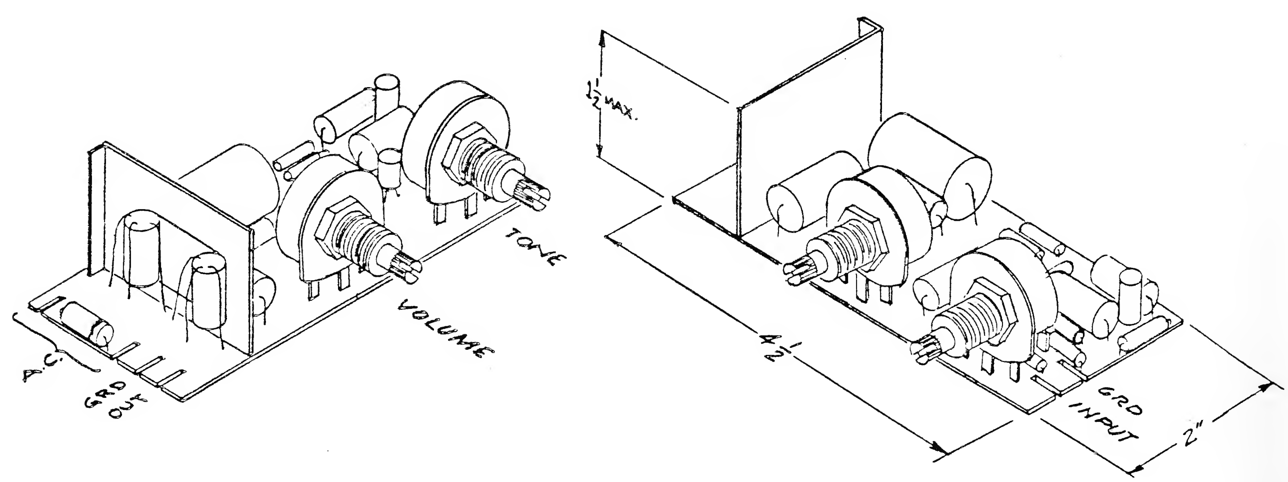
Circuit Diagram:	Half Wave
Filter Capacitor:	C = 1000 uf
Silicon Diodes:	use 500 ma
DC Voltage Output:	14.5V max @ 12 ma 12.5V min @ 210 ma

This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.





PCA-4-14

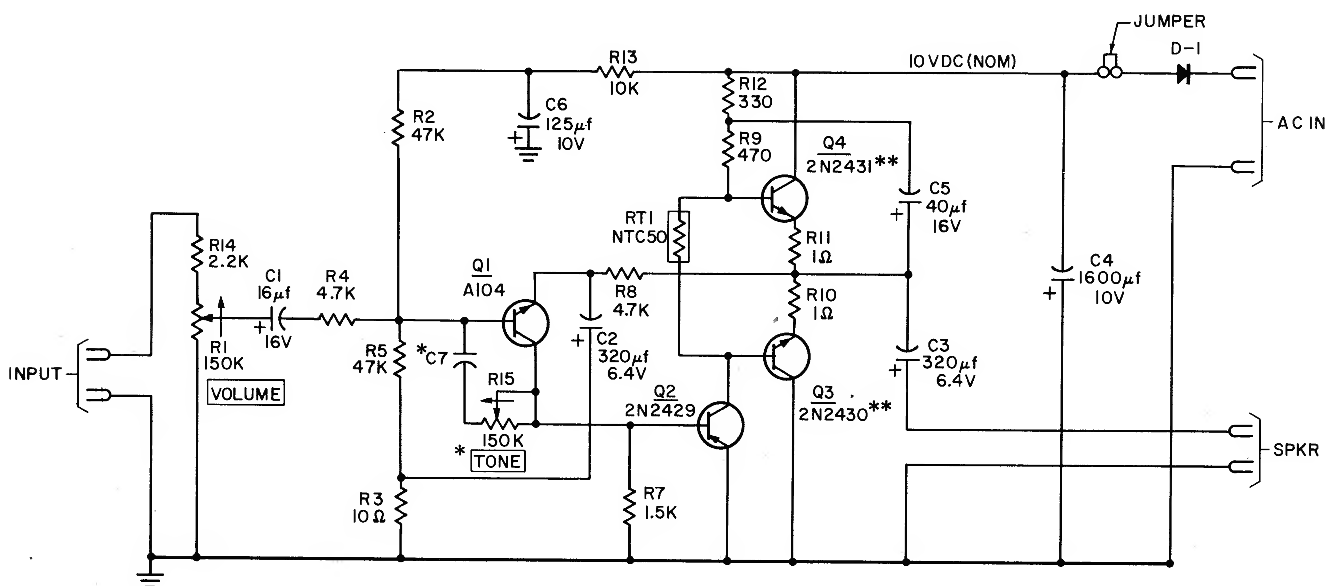


PCA-4-14

GENERAL SPECIFICATION FOR PCA-4-9

Supply Voltage:	10V DC (Regulated for measurement purposes)
Load Impedance:	8 ohms
Input Impedance:	25K ohms avg 20K ohms min
Input Sensitivity for 0.92W:	0.035V avg 0.040V max
Power Output:	0.92W @ 10% distortion @ 1 KHz @ 8 ohms
Idle Current:	10 ma
Maximum Current for 0.92W:	170 ma
Frequency Response:	@ 0.5W @ 8 ohms
	50 Hz - 20 KHz @ -3 db
Tone Controls: (optional)	Treble + 0 db -12 db @ 10 KHz
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms

0.1W	1.8%
0.5W	4.5%
0.75W	6.5%
1.0W	12.0%

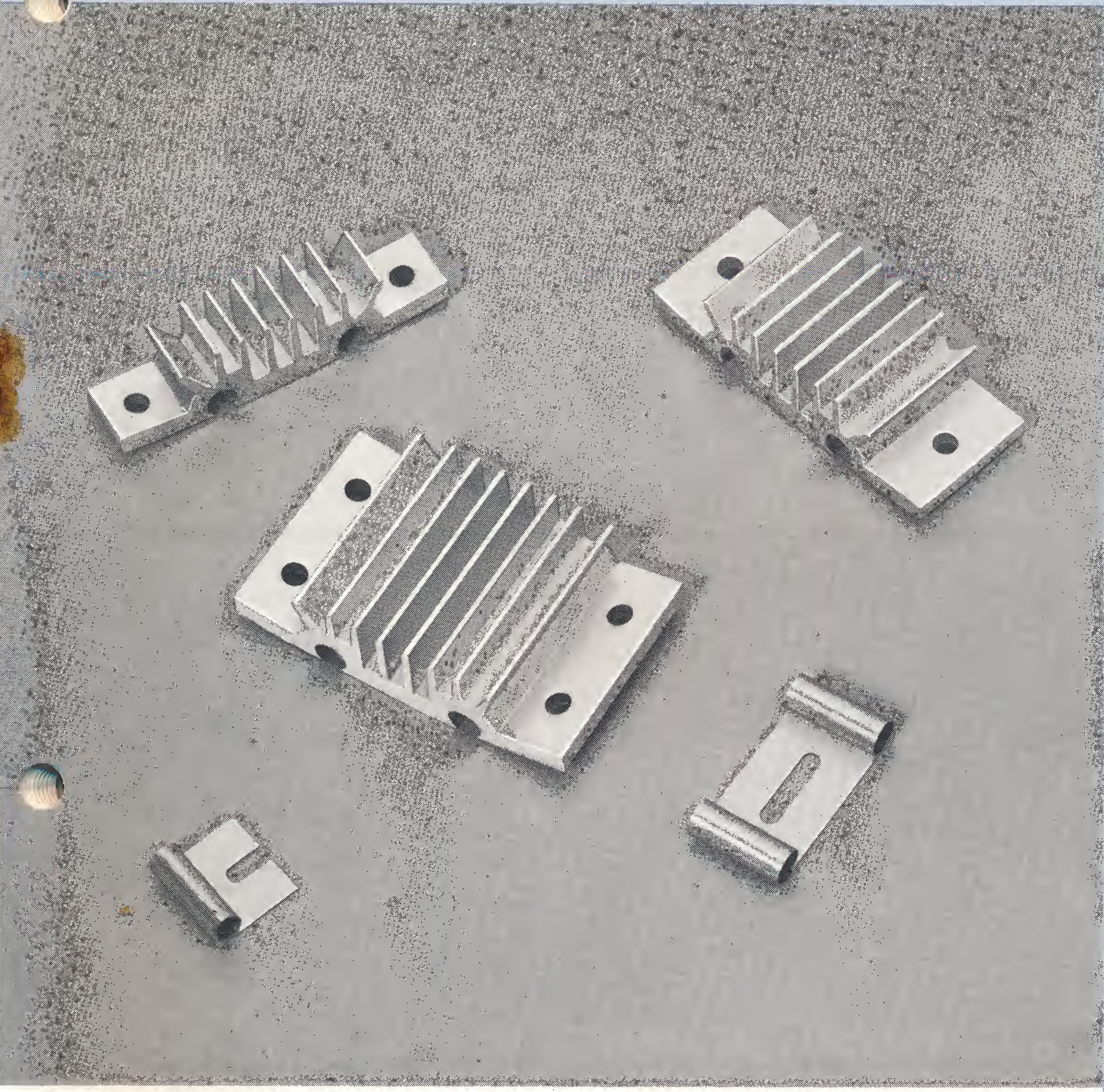


*TONE CONTROL CIRCUIT IS OPTIONAL

**AVAILABLE AS A MATCHED PAIR 2N4133.

Amperex® ELECTRONIC CORPORATION
SEMICONDUCTOR AND RECEIVING TUBE DIVISION
SLATERSVILLE, RHODE ISLAND 02876 401/POplar 2-9000

TRANSISTOR HEAT SINKS



Amperex Extruded Aluminum Heat Sinks

- Grip the transistor for better bond
- Provide maximum heat dissipation
- Are installed easily
- Are available in three sizes. (Custom made Heat Sinks are also available)

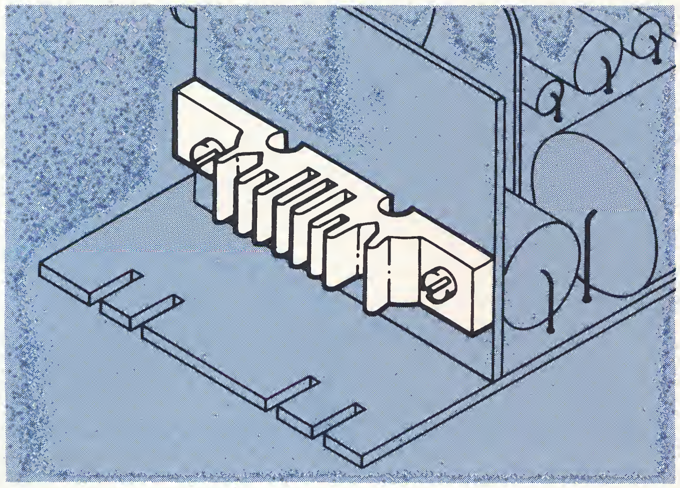
For lower cooling demands, Amperex clip-on Cooling Fins of Nickel Plated Brass

- Fit into smaller areas
- Are available in two types for single or dual transistor mounting

TRANSISTOR

Heat Sinks

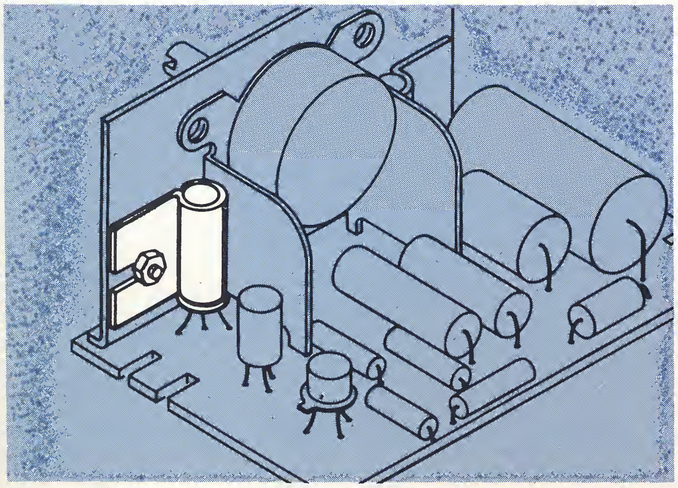
typical installations



AMPEREX

HS-3

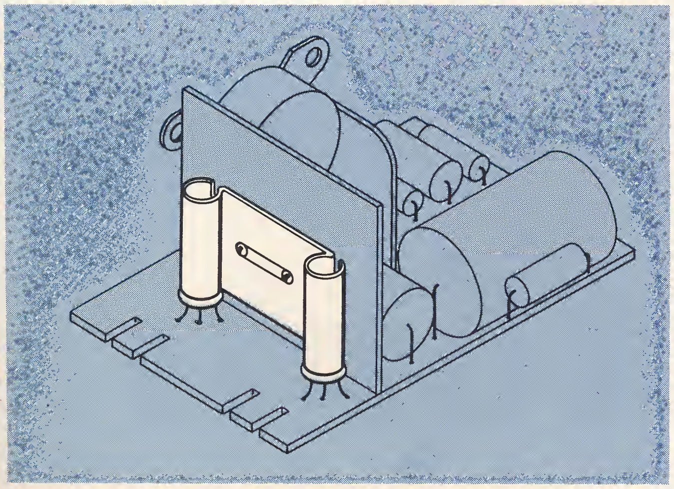
For more stringent cooling requirements. HS-3 shown holding two audio transistors for a maximum of heat dissipation.



AMPEREX

HSC-1

The single transistor Cooling Fin in a "tight spot" suggests its flexibility.



AMPEREX

HSC-2

Just as flexible and efficient as HSC-1 but holds two transistors.

Amperex® SEMICONDUCTOR & RECEIVING TUBE DIVISION

TRANSISTOR HEAT SINKS

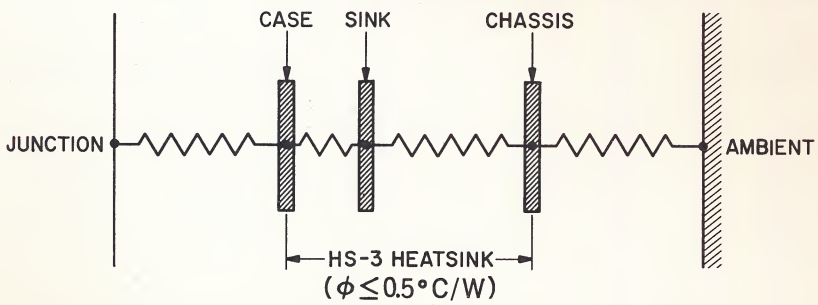
GENERAL INFORMATION

One primary factor influencing transistor power dissipation is junction temperature of the device under operating conditions. The relationship is expressed by:

$$P_d = \frac{T_J\ MAX - T_A}{\emptyset}$$

where T_J MAX = maximum junction temperature
T_A = ambient temperature
$\emptyset$ = total thermal resistance

Total thermal resistance from junction to ambient is made up of a number of smaller thermal resistances in series. These are the thermal resistance from junction to case, from case to heat sink and from heat sink to ambient. The first of these (junction to case) is built into the transistor and is beyond the control of the user. Maximum power dissipation is achieved when the thermal resistance from the case to ambient is reduced to zero. This in effect, defines an "infinite heat sink" — where the case temperature is maintained at the same temperature as the ambient air.



Tackling the problem of achieving maximum transistor heat dissipation with TO-1 audio transistors Amperex has developed a low-cost line of extruded aluminum heat sinks.*

The Amperex "HS" series of heat sinks provide a low thermal resistance from case to ambient, permitting almost twice the power output of transistors used with previous heat sinks.

The Amperex extruded aluminum heat sinks are a practical commercial design. The clamping action provided by the angled configuration, provides the lowest thermal resistance possible at lowest cost. The deep cut fins provide considerable area for natural convection.

In addition, COOLING CLIPS are available for use in equipment where TO-1 transistor power requirements fall within lower ranges.

To achieve maximum heat dissipation, follow installation procedure on the next page.

*Patent pending

Amperex Extruded Aluminum Heat Sinks

- Grip the transistor for better bond
- Provide maximum heat dissipation
- Are installed easily
- Are available in three sizes. (Custom made Heat Sinks are also available)

For lower cooling demands, Amperex clip-on Cooling Fins of Nickel Plated Brass

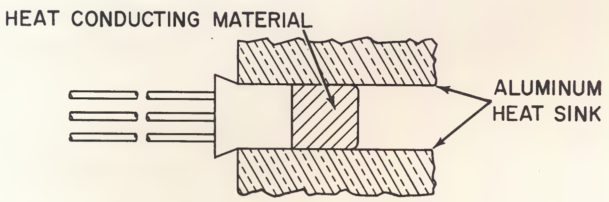
- Fit into smaller areas
- Are available in two types for single or dual transistor mounting

Amperex®

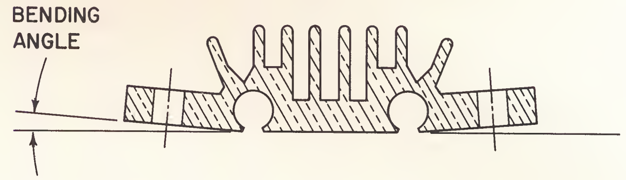
Heat Sink Data

INSTALLATION PROCEDURE

Installation procedure for the Amperex extruded aluminum heat sink illustrates its functional design advantages. Insert TO-1 transistors into openings, up to the flared portion (as illustrated). Attaching heat sink to chassis, or other mounting surface, pulls down the angles of the heat sink flanges, which reduces the diameter of the opening holding the transistor, thereby gripping transistor casing to produce the lowest possible thermal resistance interface between transistor casing and heat sink. Producing lowest thermal resistance interface between case and heat sink provides an economical solution to the variations encountered in case diameters and extruded heat sink openings. For all practical purposes — attaching sink to chassis, makes for an almost infinite heat sink.



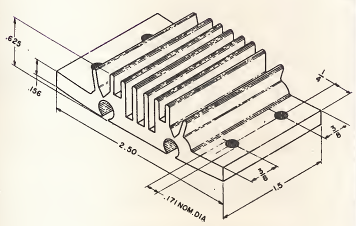
Amperex TO-1 Audio transistor inserted into extruded aluminum heat sink. Note that flared end is clear of heat sink. (Shaded area shows approximately ½ of TO-1 transistor filled with heat conducting material.)



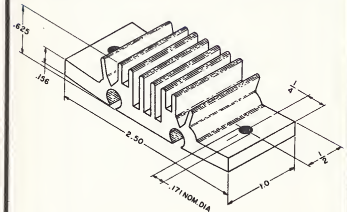
Bolting down extruded aluminum flanges produces tight bond which effectively reduces thermal resistance between case and ambient.

Heat Sink Specifications

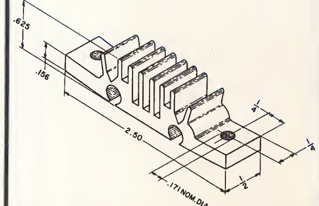
EXTRUDED ALUMINUM



HS-1

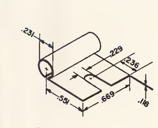


HS-2

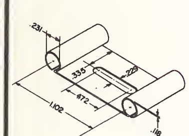


HS-3

CLIP ON HEAT SINK



HSC-1



HSC-2

Note: All measurements are made at ambient temperatures between 30° and 50°C.

HEAT SINKS MEASURED IN FREE AIR

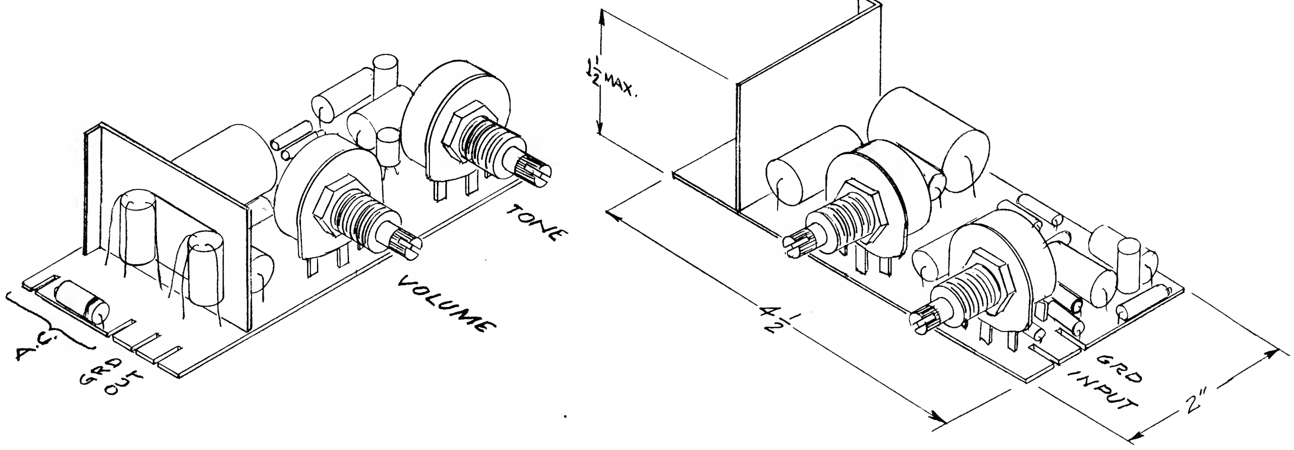
PART NO.	DESCRIPTION	AMBIENT TEMPERATURE
HSC-1	Single clip-on, one transistor	43°C/W

HEAT SINKS MOUNTED ON 2½ x 2½ x 3/32 ALUMINUM PLATE (which has a thermal resistance of approx. 12° C/W)

		THERMAL RESISTANCE FROM CASE TO AMBIENT
HSC-2	Dual clip-on, two transistors	20°C/W
HS-3	½-inch extruded aluminum, two transistors	12°C/W

Amperex®
ELECTRONIC CORPORATION

GENERAL SPECIFICATION FOR PCA-4-9 (Continued)

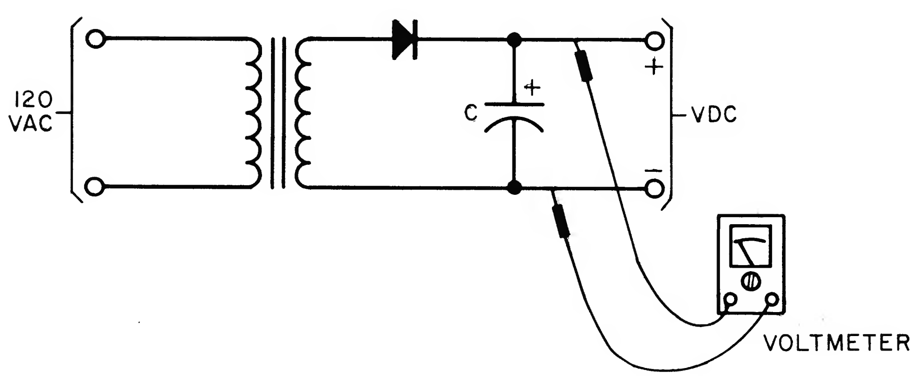


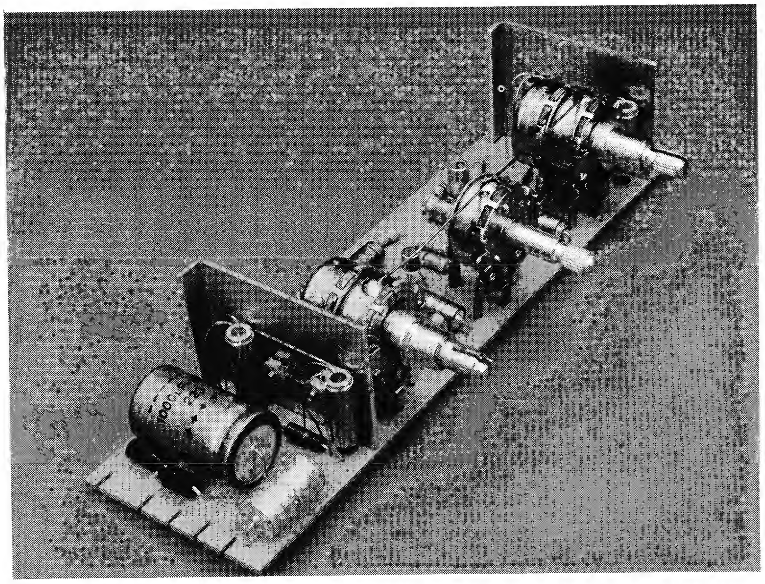
PCA-4-9

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-4-9

Circuit Diagram:	Half Wave
Filter Capacitor:	C = 1600 uf
Silicon Diodes:	500 ma
DC Voltage Output:	11V max @ 10 ma 8.8V min @ 160 ma

This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.





TENTATIVE SPECIFICATION FOR PCA-5A-14

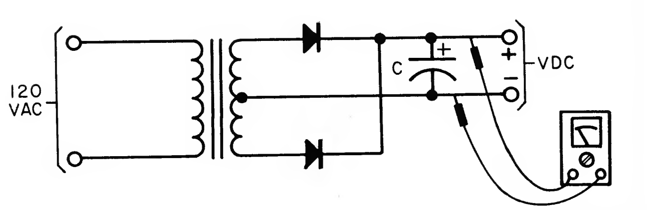
Supply Voltage:	14V DC (Regulated for measurement purposes)
Load Impedance:	8 ohms
Input Impedance:	600K ohms avg 330K ohms min
Input Sensitivity for 1.8W:	1.0V avg
Power Output:	1.8W @ 10% distortion @ 1 KHz @ 8 ohms
Idle Current:	20 ma
Maximum Current for 1.8W:	210 ma
Frequency Response:	@ 1W @8 ohms 100 Hz - 40 KHz @ -3 db
Tone Controls:	Treble + 0 db -12 db @10 KHz
Power vs Total Harmonic Distortion:	@1 KHz @8 ohms

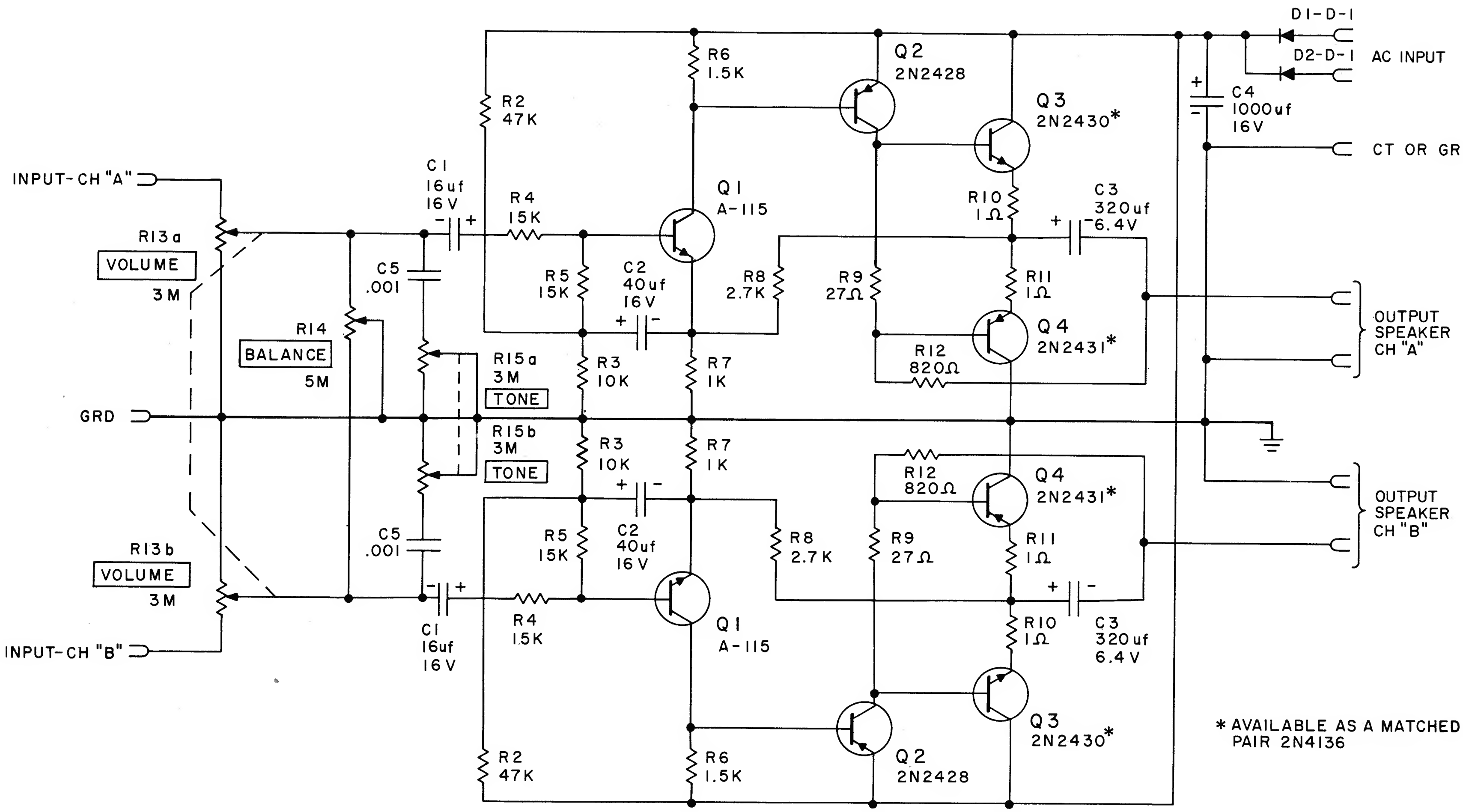
0.1W	0.25%
0.5W	0.55%
1.0W	0.95%
1.5W	2.2%
2.0W	12.0%

SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-5A-14

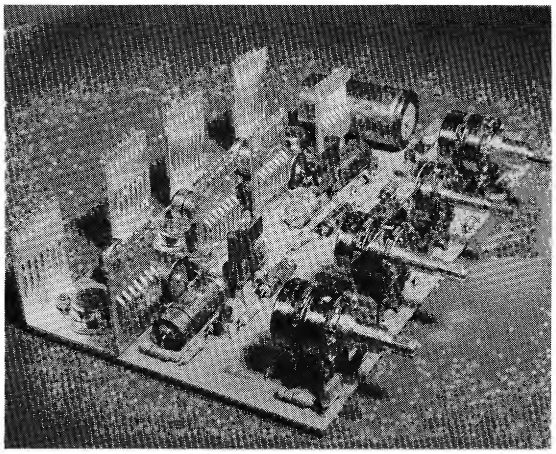
Circuit Diagram:	Full Wave Center Tapped Secondary
Filter Capacitor:	C = 1000 uf
Silicon Diodes:	use 500 ma
DC Voltage Output:	14.5V max @ 20 ma 12.0V min @450 ma

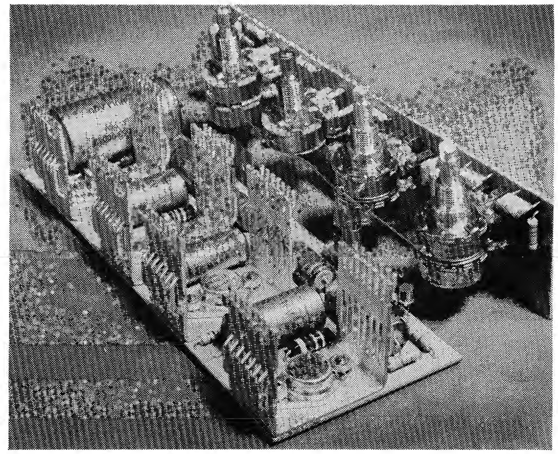
This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.





D1-D-1
D2-D-1
AC INPUT
R6
1.5K
Q2
2N2428
Q3
2N2430*
C4
1000uf
16V
CT OR GRD
R2
47K
C1
16uf
16V
Q1
A-115
R4
15K
R10
1Ω
C3
320uf
6.4V
INPUT-CH "A"
R13a
VOLUME
3M
C5
.001
R5
15K
C2
40uf
16V
R8
2.7K
R9
27Ω
R11
1Ω
Q4
2N2431*
OUTPUT
SPEAKER
CH "A"
R14
BALANCE
5M
R15a
3M
TONE
R3
10K
R7
1K
R12
820Ω
GRD
R15b
3M
TONE
R3
10K
R7
1K
R12
820Ω
Q4
2N2431*
OUTPUT
SPEAKER
CH "B"
C5
.001
R5
15K
C2
40uf
16V
R8
2.7K
R9
27Ω
R11
1Ω
R13b
VOLUME
3M
INPUT-CH "B"
C1
16uf
16V
R4
1.5K
Q1
A-115
R10
1Ω
C3
320uf
6.4V
Q3
2N2430*
* AVAILABLE AS A MATCHED
PAIR 2N4136
R2
47K
R6
1.5K
Q2
2N2428





TENTATIVE SPECIFICATION FOR PCA-6A-25

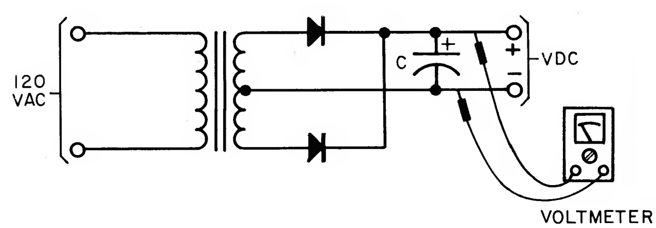
Supply Voltage:	25V DC (Regulated for measurement purposes)
Load Impedance:	8 ohms
Input Impedance:	500K ohms avg
Input Sensitivity for 9.5W:	0.5V avg
Power Output:	9.5W @ 10% distortion 1 KHz @ 8 ohms
Idle Current:	35 ma
Maximum Current for 9.5W:	560 ma
Frequency Response:	@ 1W @ 8 ohms 30 Hz - 40 KHz @ -3 db
Tone Controls:	Treble + 3 db -14 db @ 10 KHz Base + 10 db -10 db @ 100 Hz
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms

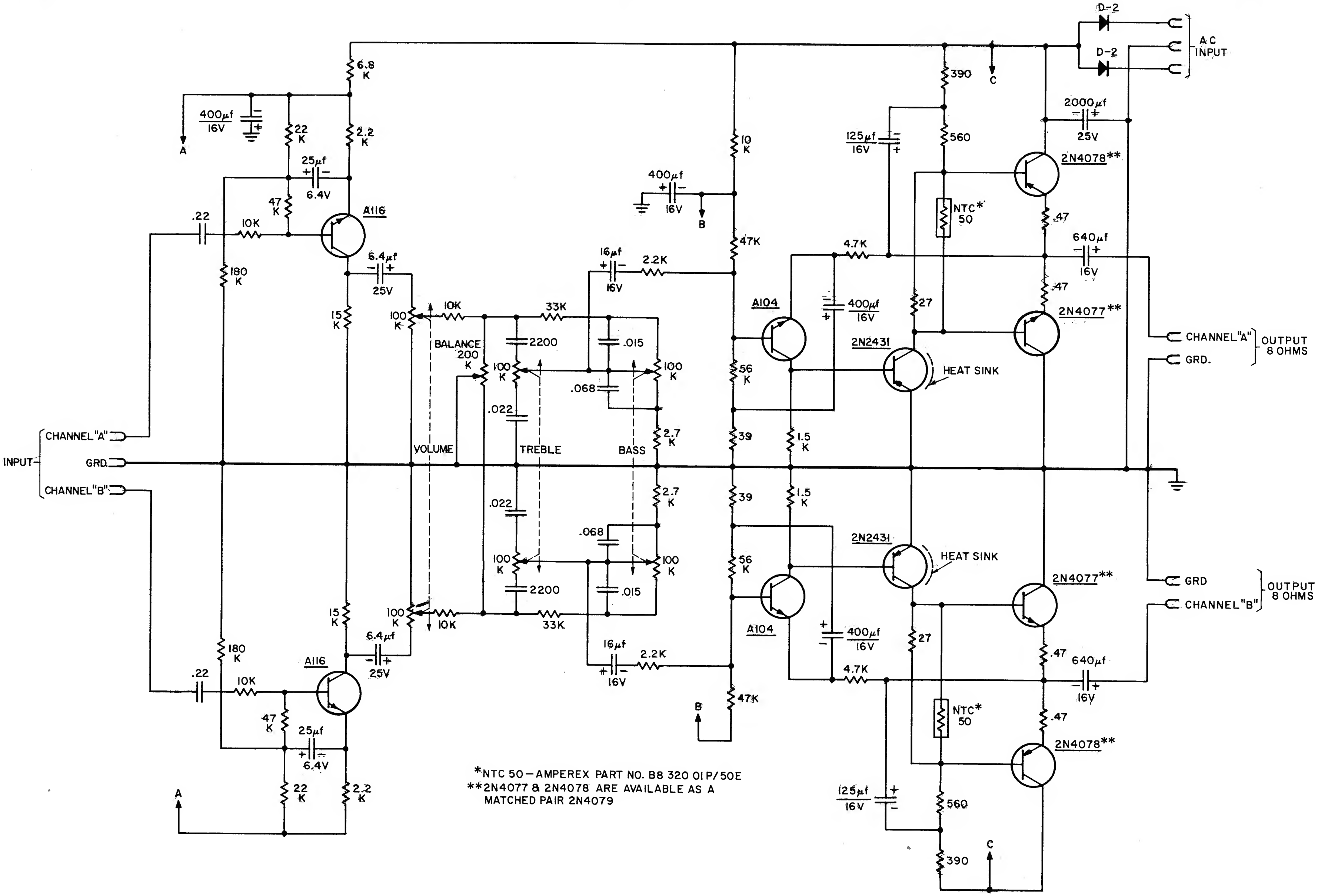
0.1W	0.6%
1.0W	0.5%
2.5W	1.1%
5.0W	2.0%
7.5W	3.2%
9.5W	10.0%

TENTATIVE SUGGESTED POWER TRANSFORMER SPECIFICATIONS FOR PCA-6A-25

Circuit Diagram:	Full Wave Center Tapped Secondary
Filter Capacitor:	C = 2000 uf
Silicon Diodes:	750 ma
DC Voltage Output:	26V max @ 40 ma 23V min @ 1.1 amps

This power supply feeds a Class B amplifier so that temperature rise may be measured at 60% of full output.



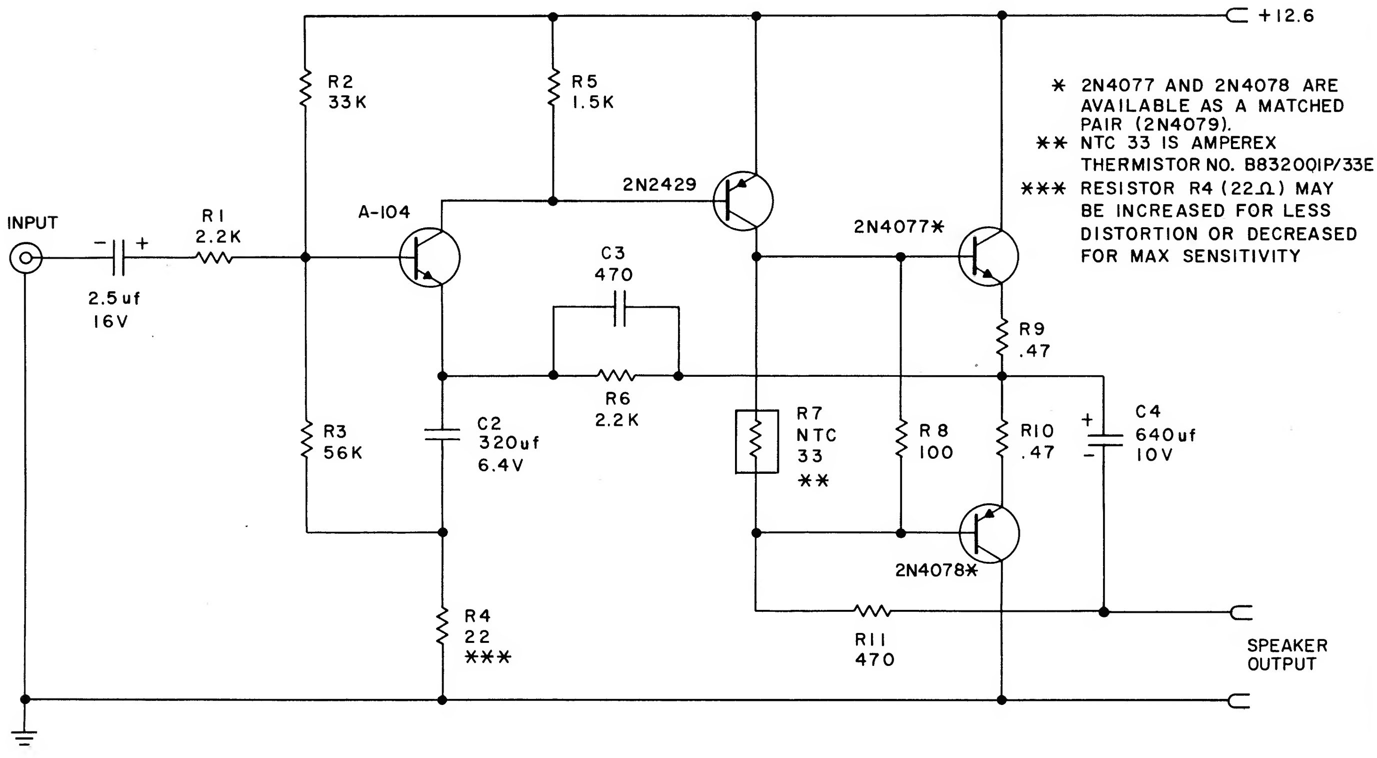


D-2
D-2
AC INPUT
6.8 K
400μf 16V
A
22 K
2.2 K
25μf 6.4V
47 K
A116
.22
10K
180 K
6.4μf 25V
15 K
100 K
10K
33K
BALANCE 200 K
2200
.015
100 K
.068
.022
16μf 16V
2.2K
10 K
400μf 16V
B
47K
A104
56 K
39
1.5 K
2.7 K
VOLUME
TREBLE
BASS
390
C
560
125μf 16V
2000μf 25V
2N4078**
NTC* 50
.47
4.7K
640μf 16V
27
2N4077**
2N2431
HEAT SINK
CHANNEL "A"
GRD.
OUTPUT 8 OHMS
INPUT
CHANNEL "A"
GRD.
CHANNEL "B"
GRD
CHANNEL "B"
*NTC 50—AMPEREX PART NO. B8 320 01P/50E
**2N4077 & 2N4078 ARE AVAILABLE AS A MATCHED PAIR 2N4079

GENERAL SPECIFICATION FOR 5W AUTO RADIO OUTPUT

Supply Voltage:	12.6 - 13.6V
Load Impedance:	3.2 - 4.0 ohms
Input Impedance:	20K ohms
Input Sensitivity for 4 W:	0.085V RMS
Power Output:	4W @ 10% distortion @ 1 KHz @ 4.0 ohms 5W @ 10% distortion @ 1 KHz @ 3.2 ohms
Idle Current:	20 - 26 ma
Maximum Current for 4W:	540 ma
Frequency Response:	@ 1W @ 4 ohms 65 Hz - 25 KHz @ -3 db (640 uf output)
Maximum Temperature:	60°C (140°F) @ 12.6V
Power vs Total Harmonic Distortion:	@ 1 KHz @ 4 ohms

0.1W	1.2%
0.5W	1.4%
1.0W	1.5%
2.5W	2.2%
3.5W	5.0%
4.0W	10.0%

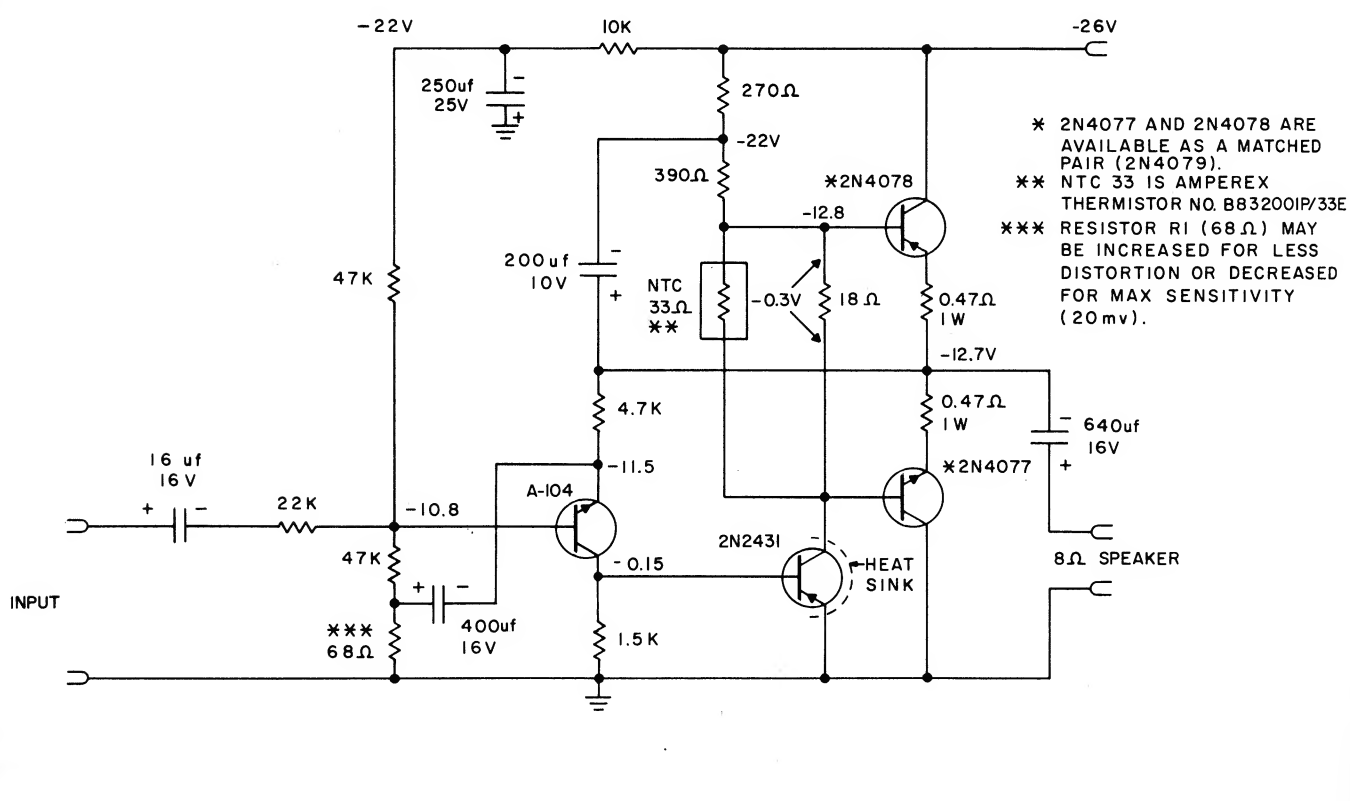


BASIC 5W AUTO RADIO AMPLIFIER

GENERAL SPECIFICATION FOR 10W COMPLEMENTARY SYMMETRY AMPLIFIER

Supply Voltage:	26V
Load Impedance:	8 ohms
Input Impedance:	40K ohms min.
Input Sensitivity for 10W:	0.20V RMS
Power Output:	10W @ 6.3% distortion @ 1 KHz @ 8 ohms
Idle Current:	30 ma
Maximum Current for 10W:	560 ma
Frequency Response:	@ 1W @ 8 ohms 24 Hz - 65 KHz @ -3 db
Power vs Total Harmonic Distortion:	@ 1 KHz @ 8 ohms

0.1W	0.20%
0.5W	0.42%
1.0W	0.62%
2.5W	1.0 %
5.0W	1.5 %
7.5W	2.2 %
10.0W	6.3 %

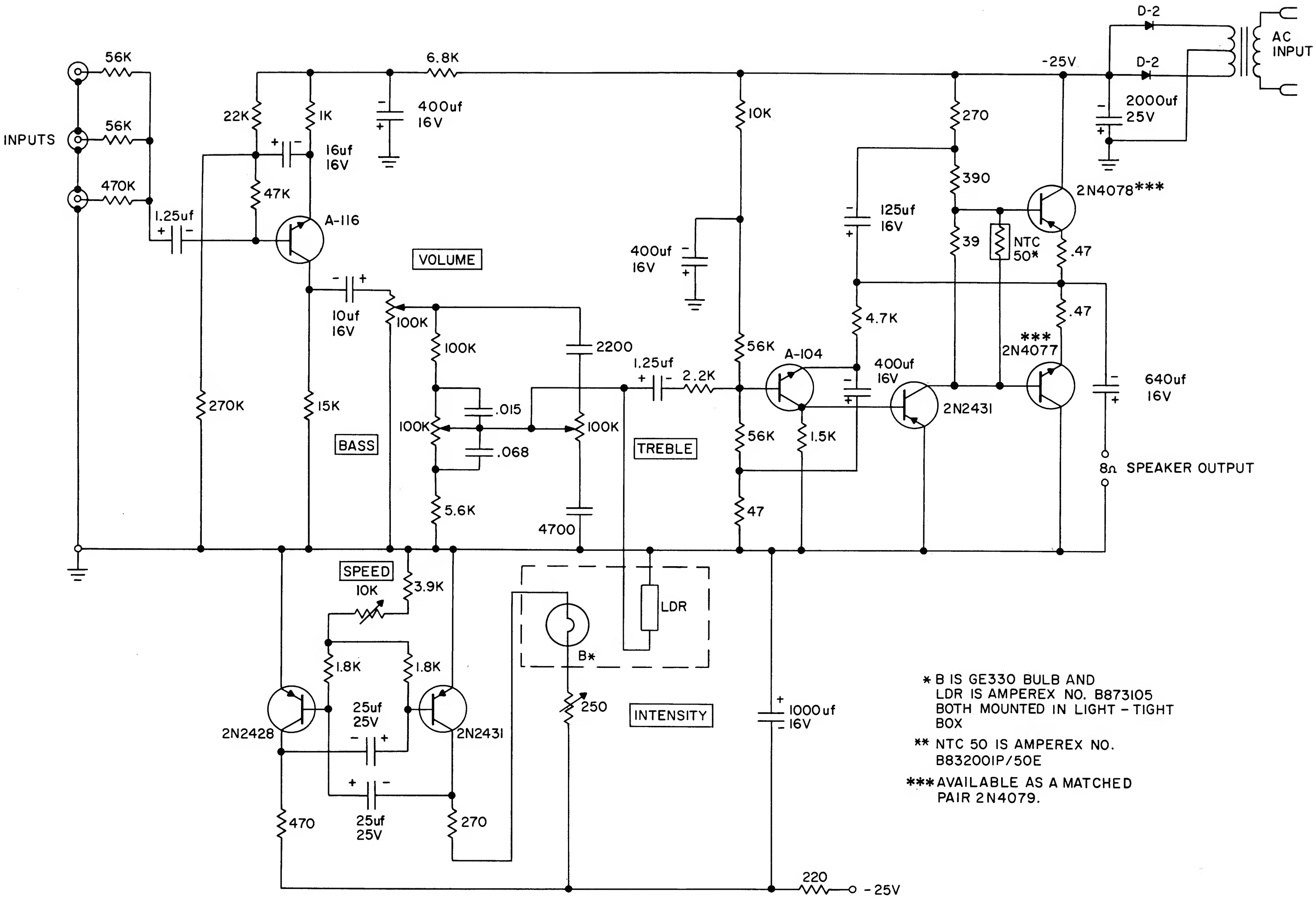


COMPLEMENTARY SYMMETRY BASIC AMPLIFIER

GENERAL SPECIFICATION FOR GUITAR AMPLIFIER WITH TREMOLO

Supply Voltage:	25V @ 70 ma 23.8V @ 550 ma
Load Impedance:	8 ohms
Input Impedance:	three inputs; two at 150K ohms min; one at 560K ohms min.
Input Sensitivity for 5W:	100 mV
Frequency Response:	@ 1W @ 8 ohms 20 Hz - 30 KHz @ -3 db
Tone Controls:	Treble +13 db -10 db Bass + 1 db -10 db
Tremolo Range:	2-7 Hz
Overload:	0.5V RMS
Modulation:	2 Hz 90% 7 Hz 40%
Power vs Total Harmonic Distortion:	@ above supply regulation

0.1W	1.2%
0.5W	0.8%
1.0W	0.7%
2.5W	1.0%
5.0W	1.8%
7.5W	5.6%
8.2W	10.0%



8W GUITAR AMPLIFIER WITH TREMOLO

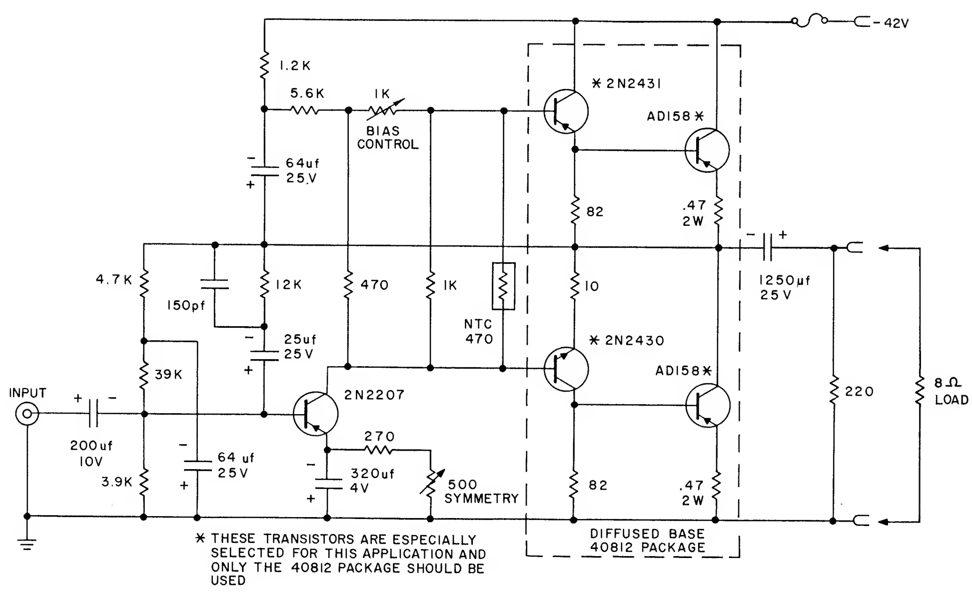
TENTATIVE

GENERAL SPECIFICATION FOR 20 WATT HI-FI AMPLIFIER USING THE 40812 KIT

Supply Voltage:	42V DC (Regulated for measurement purposes)
Load Impedance:	8 ohms
Input Impedance:	2.2K ohms min
Input Sensitivity for 20W:	2.5V RMS @ 8 ohms
Power Output:	28W @ 10% distortion @ 1KHz @ 8 ohms 25W @ 5% distortion @ 1KHz @ 8 ohms 20W @ 1% distortion @ 1KHz @ 8 ohms
Frequency Response:	@ 1W @ 8 ohms 16 Hz - 55 KHz @ -3db
Power vs Total Harmonic Distortion:	@ 8 ohms

Power	20 Hz	50 Hz	100 Hz	1 KHz	10 KHz	20 KHz
0.1W	.65	.55	.42	.25	.30	.30
0.5W	.65	.55	.42	.25	.30	.30
1W	.60	.55	.42	.25	.30	.30
5W	.65	.55	.45	.25	.33	.30
10W	.90	.58	.48	.25	.38	.35
12W	1.00	--	--	--	--	--
15W	--	.65	.52	.32	.48	.58
17W	--	1.00	--	--	--	1.00
20W	--	--	1.00	1.00	1.20	--

Rise Time:	4 usec (Fall 4 usec.)
Fuse:	1A for music operation only



BASIC AMPLIFIER 20W Hi-Fi

TECHNICAL DATA - TRANSISTORS

(PAGES 30-38)

TENTATIVE

GENERAL DESCRIPTION

The Amperex A-105 thru A-110 are NPN silicon planar transistors in a TO-18 case intended for use as low level audio amplifiers and drivers.

ELECTRICAL CHARACTERISTICS (T = 25°C)

	Symbol	Min	Max	Units
Base-Emitter Bias Voltage I_C = 1 ma, I_b = 0.1 ma	V_{BE}	0.6	0.8	Volts
Collector-Emitter Breakdown Voltage I_C = 10 ma	BV_{CEO}	20	--	Volts
Collector-Base Leakage Current V_{CB} = 20V	I_{CBO}	--	100	na
Collector-Emitter Leakage Current V_{CE} = 5V, I_b = 0	I_{CEO}	--	50	na
Emitter-Base Leakage Current V_{EB} = 4V	I_{EBO}	--	100	na
Static Forward Current Transfer Ratio I_C = 5 ma, V_{CE} = 5V	h_{FE}			
	(A-105, A-106)	90	220	
	(A-107, A-108)	180	440	
	(A-109, A-110)	360	880	
Collector-Emitter Saturation Voltage I_C = 5 ma, I_b = 0.5 ma	$V_{CE(sat)}$ (A-106, A-108, A-110)		0.25	Volts
I_C = 1 ma, I_b = 0.1 ma	(A-105, A-107, A-109)		0.35	Volts

The A-106, A-108 and A-110 have low saturation voltages for audio driver applications.

TENTATIVE

GENERAL DESCRIPTION

The Amperex A-104, A-115, and A-116 are NPN silicon planar transistors in a TO-18 case intended for use as a low level audio amplifier. Characterized by a high gain at 100 microamperes, these transistors also feature a low noise figure, making them particularly useful in preamplifier input stages.

ELECTRICAL CHARACTERISTICS (T = 25°C)

	Symbol	Min	Max	Units
Base-Emitter Bias Voltage I_C = 1 ma, I_b = 0. 1 ma	V_{BE}	0. 6	0. 8	Volts
Collector-Emitter Breakdown Voltage I_C = 10 ma	BV_{CEO}	20	--	Volts
Collector-Base Leakage Current V_{CB} = 20V	I_{CBO}	--	100	na
Collector-Emitter Leakage Current V_{CE} = 5V, I_b 0	I_{CEO}	--	50	na
Emitter-Base Leakage Current V_{EB} = 4V	I_{EBO}	--	100	na
Static Forward Current Transfer Ratio I_C = 100ua, V_{CE} 5V	h_{FE}(A-104)	100	300	
	(A-115)	50	100	
	(A-116)	100	300	
Wide Band Noise Figure I_C = 10ua	WBNF(A-104)		4	db
	(A-115)		4	db
	(A-116)		*	db

*A-116 is controlled for very low $\frac{1}{f}$ noise.

TENTATIVE

GENERAL DESCRIPTION

The Amperex A-111 is an NPN silicon epitaxial transistor in a TO-18 case, intended for use in medium current audio amplifier stages. Characterized by a high gain at 20 milliamperes, the A-111 also features a low saturation voltage, making it particularly useful in driver stages.

ELECTRICAL CHARACTERISTICS (T = 25°C)

	Symbol	Min	Max	Units
Collector-Emitter Saturation Voltage $I_C = 20$ ma, $I_b = 2$ ma	$V_{CE(sat)}$	--	0.35	Volts
Collector-Emitter Breakdown Voltage $I_C = 10$ ma	BV_{CEO}	30	--	Volts
Collector-Base Leakage Current $V_{CB} = 20V$	I_{CBO}	--	100	na
Collector-Emitter Leakage Current $V_{CE} = 5V$, $I_b = 0$	I_{CEO}	--	50	na
Emitter-Base Leakage Current $V_{EB} = 4V$	I_{EBO}	--	100	na
Static Forward Current Transfer Ratio $I_C = 20$ ma, $V_{CE} = 5V$	h_{FE}	180	440	

TENTATIVE

GENERAL DESCRIPTION

The Amperex AD158 is an alloy-diffused PNP germanium power transistor in a TO-3 case, intended for use in the Class B output stage of Hi-Fi Amplifiers.

ABSOLUTE MAXIMUM RATINGS

	Symbol	Value
Collector-Base Voltage	V_{CB}	75 Volts
Collector Current	I_C	5. 0 amp
Base Current	I_B	0. 5 amp
Power Dissipation (T_{MB} = 81°C)	P_C	12. 5 watts
Junction Temperature		
Operating	T_j	100°C
Storage	T_{stg}	-35 to 100°C

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

	Symbol	Min	Max	Units
Thermal Derating Factor	T_{jc}	--	1. 5°	c/w
Collector Cut-off Current				
V_{CB} = 0. 5V, I_E = 0	I_{CBO}	--	0. 2	ma
V_{CB} = 15V, I_E = 0, Tj = 100°C	I_{CBO}	--	25	ma
Collector-Base Breakdown Voltage				
I_C = 10 ma, V_{BE} = 1V	BV_{CBO}	75	--	Volts
Collector-Emitter Breakdown Voltage				
I_C = 2 amp, I_B = 0	BV_{CEO}	40	--	Volts
Emitter-Base Breakdown Voltage				
I_{EB} = 10 ma, I_C = 0	BV_{EBO}	2. 5	--	Volts
Forward Current Transfer Ratio				
I_E = 30 ma, V_{CB} = 14V	h_{FE}	40	300	
I_E = 1 amp, V_{CB} = 2V	h_{FE}	75	220	
I_E = 3 amp, V_{CB} = 2V	h_{FE}	40	160	
Base Input Voltage				
I_E = 30 ma, V_{CB} = 14V	V_{BE}	170	210	mV

DYNAMIC ELECTRICAL CHARACTERISTICS (T_A = 25°C)

	Symbol	Typ	Units
Cut-off Frequency			
I_E = 0. 5 amp, V_{CB} = 2V	f_t	20	mc

Consisting of
1 - 2N2430 (NPN)
2 - 2N2706 (PNP)

TENTATIVE DATA

GENERAL DESCRIPTION

The 2N2707 is a complementary (NPN-PNP) matched pair of germanium (TO-1) transistors intended for use in transformerless audio output or driver stages. It can deliver 1 watt of sine wave power into a 8 or 16 ohm load.

Absolute Maximum Ratings

Collector-Base Voltage	V_{CBO}	32V
Emitter-Base Voltage	V_{EBO}	10V
Collector Current	I_C	200 ma.
Base Current	I_B	10 ma.
Storage & Operating Tem. Range (junction)	T_j	-65° to 100°C

ELECTRICAL CHARACTERISTICS 25°C

		Min.	Typ.	Max.
Forward Current Transfer Ratio (I_C = 50 ma., V_{CB} = 0)	h_{FE}	65	--	200
Collector-Base Leakage (V_{CB} = 10V.)	I_{CBO}	--	--	10 μA
Freq. at which $/h_{FE}/ = 1$ (V_{CB} = 2V., I_E = 10 ma.)	f_1	1.3	--	--Mc
Collector-Emitter Knee Voltage I_c = 0.2A (I_B set for I_c = 0.22A V_{CE} = 1 V.)	$V_{CE}(sat)$	--	--	0.5V.

DEVICE DISSIPATION

Power Dissipation at 25°C ambient with cooling clip mounted to 2 1/2" x 2 1/2" x 3/32" aluminum plate.	2N2430 2N2706	0.5 watt 1.0 watt
Thermal Resistance, Junction to Case	2N2430 2N2706	110°C/watt 50°C/watt

Consisting of
1 - 2N4077 (NPN)
1 - 2N4078 (PNP)

TENTATIVE DATA

The Amperex 2N4079 is a pair of germanium transistors selected to operate in a complementary symmetry audio power output circuit.

The 2N4079 requires no input or output transformers and is capable of delivering up to 12 watts of audio in Class B operation.

ABSOLUTE MAXIMUM RATINGS

Collector-Base Voltage	V_{CBO}	32 V
Collector-Emitter Voltage	V_{CEO}	20 V
Emitter-Base Voltage	V_{EBO}	10 V
Collector Current (Cont.)	I_C	1 A
Collector Current (Peak)	I_{CM}	3 A

TEMPERATURE

Storage Temperature range, T_{stg}	-55°C to 100°C	
Operating Junction Temperature Range, T_j	-55°C to 100°C	
Lead temperature, 3/16" from case for 10 seconds		230°C

DEVICE DISSIPATION

Power dissipation at 25°C case with heat sink		7.5 W
Thermal Resistance (Junction to Case)	T_{jc}	4.5°C/watt

ELECTRICAL CHARACTERISTICS, 25°C CASE TEMPERATURE

		Min.	Max.
Collector cutoff current, (V_{CB} = 10 v, I_E = 0)	I_{CBO}		25 μa
Emitter cutoff current, (V_{EB} = 10 v, I_C = 0)	I_{EBO}		0.2 ma
Collector-emitter breakdown voltage,	BV_{CEO}	20V	

		Min.	Max.
ELECTRICAL CHARACTERISTICS, 25°C CASE TEMPERATURE			
Collector-emitter saturation voltage. (I_C = 1.0 a, I_B = 10 Ma)	$V_{CE(sat)}$		0.8 v
DC forward current transfer ratio, (I_C = 500 Ma, V_{CB} = 0 v)	h_{FE}	75	250
Base-emitter voltage, (I_C = 500 Ma, V_{CE} = 1.5 v)	V_{BE}		0.6 v
Base-emitter voltage, (for Class B operation) (I_C = 5 Ma, V_{CE} = 10 v)	V_{BE}	110	150 mv
DYNAMIC			
Gain bandwidth product, (V_{CE} = 2 v, I_C = 10 Ma)	f_T	1.0	Mc

PAIRS

Pairs are matched into h_{FE} categories at 500 ma.

2N4107

Consisting of
1 - 2N4105 (NPN)
1 - 2N4106 (PNP)

TENTATIVE DATA

GENERAL DESCRIPTION

The 2N4107 is a complementary (NPN-PNP) matched pair of germanium (TO-1) transistors, intended for use in transformerless audio output or driver stages. The 2N4107 pair mounted in a HS-3 heatsink can deliver 5 watts of power into an 8 ohm load.

ABSOLUTE MAXIMUM RATINGS

Collector-Base Voltage	V_{CBO}	25V
Collector-Emitter Voltage	V_{CEO}	15V
Emitter-Base Voltage	V_{EBO}	10V
Collector Current	I_C	1A
Peak Collector Current	I_{CM}	2A
Storage & Operating Temperature Range (junction)	T_j	-55°C to 100°C
Total Dissipation at 25°C case	P_t	1.6W
Thermal Derating Factor in HS-3 Heat Sink	T_{j-c}	35°C/W max.

ELECTRICAL CHARACTERISTICS 25°C

		Min.	Typ.	Max.
Forward Current Transfer Ratio (at I_C = 0.5 A, V_{CB} = 0)	h_{FE}	100	--	500
Collector-Base Leakage (V_{CB} = 10V)	I_{CBO}	--	--	20 μa
Freq. at which $\lvert h_{FE} \rvert = 1$ (V_{CB} = 2V, I_E = 10 ma)	f_T	--	1.5	-- Mc
Collector-Emitter Knee Voltage I_C = 1A (I_B set for I_C = 1.1A at V_{CE} = 1V)	$V_{CE\,(sat)}$	--	--	0.7V

DEVICE DISSIPATION

Power Dissipation at 25° Case	1.6 watt (each unit)
Derating Factor	40°C/watt (35°C/watt in HS-3)

2N4136

Consisting of
1 - 2N2430 (NPN)
1 - 2N2431 (PNP)

TENTATIVE DATA

GENERAL DESCRIPTION

The 2N4136 is a complementary (NPN-PNP) matched pair of germanium (TO-1) transistors, intended for use in transformerless audio output or driver stages. It can deliver 2 watts of sine wave power into a 8 ohm load.

ABSOLUTE MAXIMUM RATING

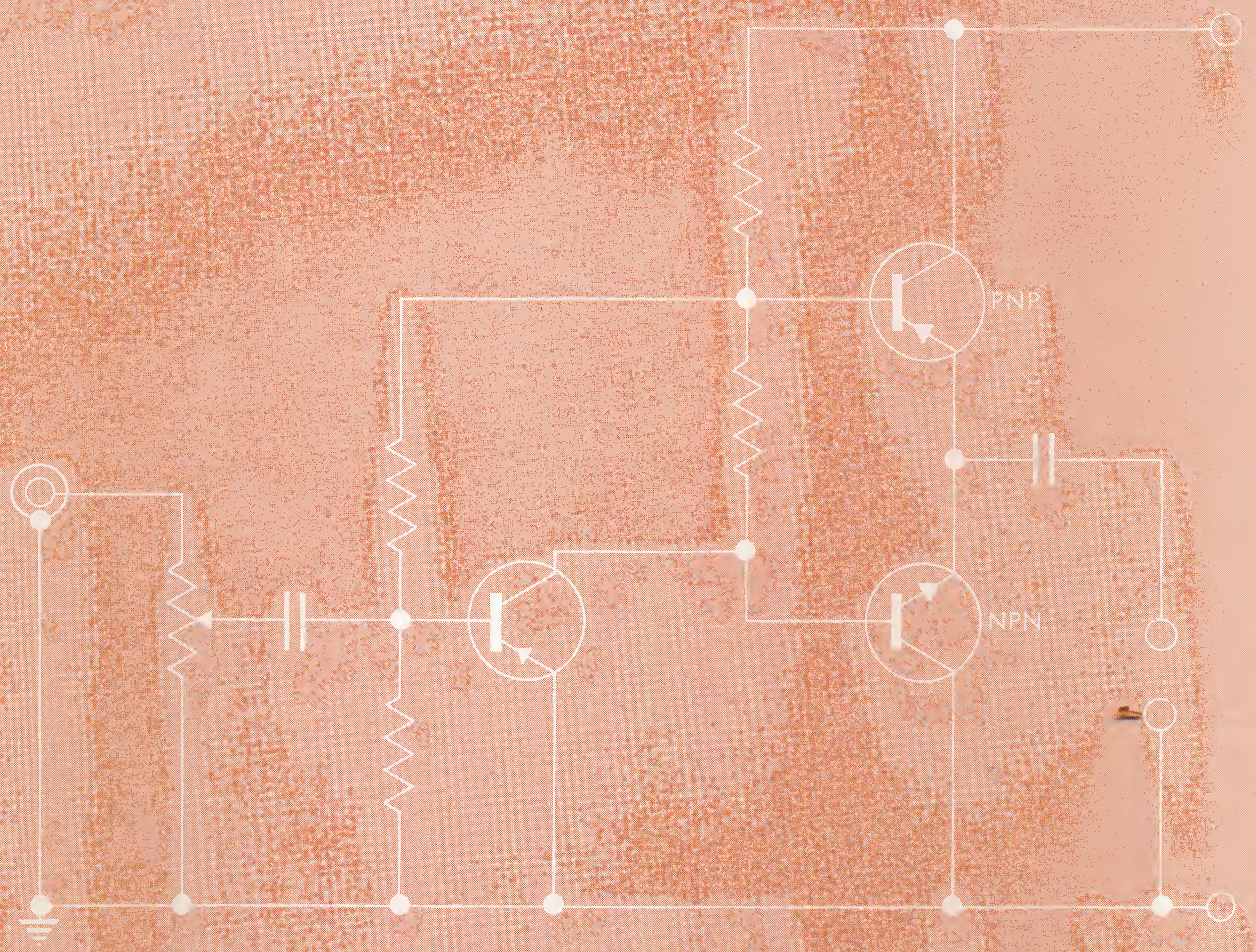
Collector-Base Voltage	V_{CBO}	32 V
Emitter-Base Voltage	V_{EBO}	10 V
Collector Current	I_C	500 ma
Base Current	I_B	25 ma
Storage & Operating Temperature Range (junction)	T_j	-65°C to 100°C

ELECTRICAL CHARACTERISTICS 25°C

		Min.	Typ.	Max.	
Forward Current Transfer Ratio (I_C = 50 ma., V_{CB} = 0)	h_{FE}	50	--	220	
Collector-Base Leakage (V_{CB} = 10V.)	I_{CB0}	--	--	15 μA	
Emitter Cutoff Current (V_{EB} = 5V.)	I_{EBO}	--	--	45 μA	
Freq. at which $/h_{FE}/ = 1$ (V_{CB} = 2V., I_E = 10 ma)	f_1	1	--	--	Mc
Collector-Emitter Knee Voltage I_C = 0.5A (I_B set for I_C = 0.55 at V_{CE} = 1V.)	V_{CE}(sat)	--	--	0.7V	

DEVICE DISSIPATION

Power Dissipation at 25°C ambient with cooling clip mounted to 2 1/2" x 2 1/2" x 3/32" aluminum plate.	2N2430 2N2431	0.5 watt 1.25 watt
Thermal Resistance, Junction to Case	2N2430 2N2431	110°C/watt 40°C/watt (35°C/watt in HS-3)



AMPEREX ELECTRONIC CORPORATION
SEMICONDUCTOR AND RECEIVING TUBE DIVISION
SLATERSVILLE, RHODE ISLAND 02876 • 401/POplar 2-9000

Amperex® ELECTRONIC CORPORATION
SLATERSVILLE, RHODE ISLAND 02876

PRINTED CIRCUIT ASSEMBLIES PRICE LIST

MODEL	1,000	5,000	10,000 and up	DESCRIPTION
PCA-1-9	$3.87	$3.52	$3.20	1W, 9V D.C. 4 Transistor Amplifier
PCA-1-14	3.87	3.52	3.20	2W, 14V D.C. 4 Transistor Amplifier
PCA-1LDC-14	3.63	3.30	3.00	Same as PCA-1-9 less rectifier and filter capacitor
PCA-2-9	3.27	2.97	2.70	3/4W, 9V D.C. 3 Transistor Amplifier
PCA-2SLDC-9	2.95	2.68	2.44	Same as PCA-2-9 with off-on switch less rectifier diode and filter capacitor
PCA-2-14	3.27	2.97	2.70	1W, 14V D.C. 3 Transistor Amplifier
PCA-2S-14	3.35	3.05	2.77	Same as PCA-2-14 with switch
PCA-2LD-14	3.18	2.89	2.63	Same as PCA-2-14 less rectifier diode
PCA-3B-18-1	10.74	9.76	8.87	4W/Channel Stereo Amplifier
PCA-4-9	4.56	4.15	3.77	1W, 9V D.C. 4 Transistor Amplifier for radio ceramic crystal
PCA-4-9A	4.92	4.47	4.07	Same as PCA-4-9 with tone control circuit
PCA-4-14	4.58	4.16	3.78	2W, 14V D.C. 4 Transistor for radio ceramic crystal
PCA-4-14A	4.94	4.49	4.08	Same as PCA-4-14 with tone control circuit
PCA-5A-14	8.70	7.91	7.19	2W/Channel 14V D.C. Stereo Amplifier with balance tone volume
PCA-6A-25	14.52	13.20	--	8W/Channel Stereo Amplifier
PCA-6A-25SCS	14.79	13.45	--	Same as PCA-6A-25 with separate control
PCA-6B-18	13.64*	12.40*	--	Same as PCA-3B-18-1 with pre-amp for ceramic cartridge

(OVER)

PRINTED CIRCUIT ASSEMBLIES PRICE LIST
(Continued)

MODEL	1,000	5,000	10,000 and up	DESCRIPTION
PCA-7B	$7.78	$7.07	$6.43	Tape cartridge pre-amplifier stereo
PCA-8	10.02*	9.11*	8.28*	20W Mono Amplifier
PCR-1-9	6.72	6.11	5.55	9V - 2 Transistor AM Tuner

*Tentative Pricing

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