ELECTRON TUBES

RCA Application Note

AN-180

Use of RCA Power Pentodes 6EH5, 12EH5, 25EH5, and 50EH5 In Low-Cost Audio Amplifiers

This Note discusses the application of a family of new power pentodes designed for audio amplifiers in which small size and unusually high power sensitivity at low supply voltages are primary design considerations. Among the applications discussed are an economy phonograph amplifier, a low-cost "hi-fi" amplifier (including stereophonic system), and ac-dc table-model radios. The circuits for an economy phonograph amplifier and low-cost "hi-fi" amplifier are given.

Tube Characteristics and General Considerations

The RCA-6EH5, -12EH5, -25EH5, and -50EH5 are power pentodes of the 7-pin miniature type. At low plate and screen-grid voltages, these tubes are capable of providing relatively high power output with a small af grid-No.1 driving voltage. The 6EH5, 25EH5, and 50EH5 types are alike except for heater ratings; the type 12EH5 has a controlled heater-warmup time and a high heater-cathode voltage rating (300 volts) for use in the audio-output stage of "stacked B+" television receivers (af output tube in series with dc supply to the if tubes). Technical data for these tubes, including Maximum Ratings and Typical Operation Values, are given in Table I. Values are also given for the operation of two tubes in push-pull class AB_1 circuits.

Because of the exceptionally high transconductance of these tubes (14,600 micromhos under typical operating conditions), the use of long leads or poor lead dress can give rise to certain types of parasitic oscillations. Because these oscillations may occur at very high frequencies (possibly up to 10 megacycles per second), their only noticeable effect will be high distortion and a loss of power output. Occasionally, the oscillations may be accompanied by a high bias developed on grid-No.1. Such oscillations can usually be prevented by the use of suppressor resistors in series with the grid-No.1 and/or grid-No.2 leads. These resistors should be wired as close to the socket as possible, preferably with no more than 0.25 inch of exposed lead. Although the circuits given in this Note include these resistors, it should be pointed out that they are not an absolute necessity and can be omitted in a carefully arranged circuit.

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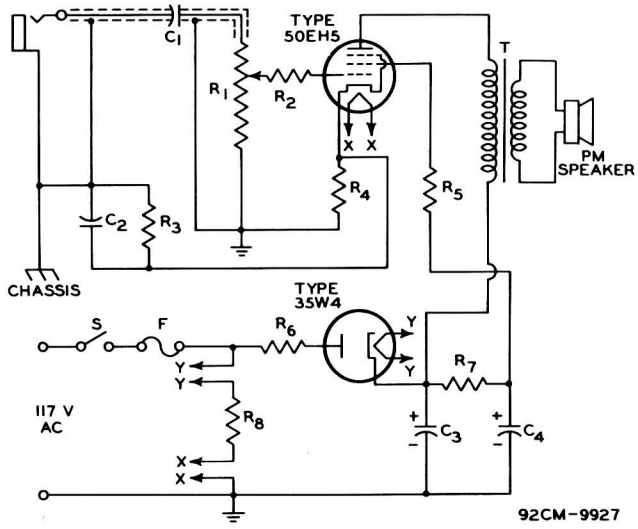
Like other power handling tubes, these types require a certain amount of care in installation to assure an adequate supply of air for proper cooling. Care also should be exercised in layout so that the tube is not placed too close to apparatus such as motors or ac line transformers which generate large magnetic fields.



C_1: 0.02 μf, paper, 400 volts
C_2: 0.082 μf, paper, 400 volts
C_3 C_4: 40 μf, electrolytic, 150 volts
F: Fuse, 1 amp
J: Crystal pickup
R_1: Potentiometer, 500,000 ohms, audio taper
R_2: 10,000 ohms, 0.5 watt
R_3: 220 ohms, 0.5 watt
R_4 R_5: 56 ohms, 0.5 watt
R_6: 22 ohms, 0.5 watt
R_7: 3300 ohms, 1 watt
R_8: 210 ohms, 0.5 watt
T: Output transformer, primary impedance 3000 ohms, secondary impedance to match speaker voice coil

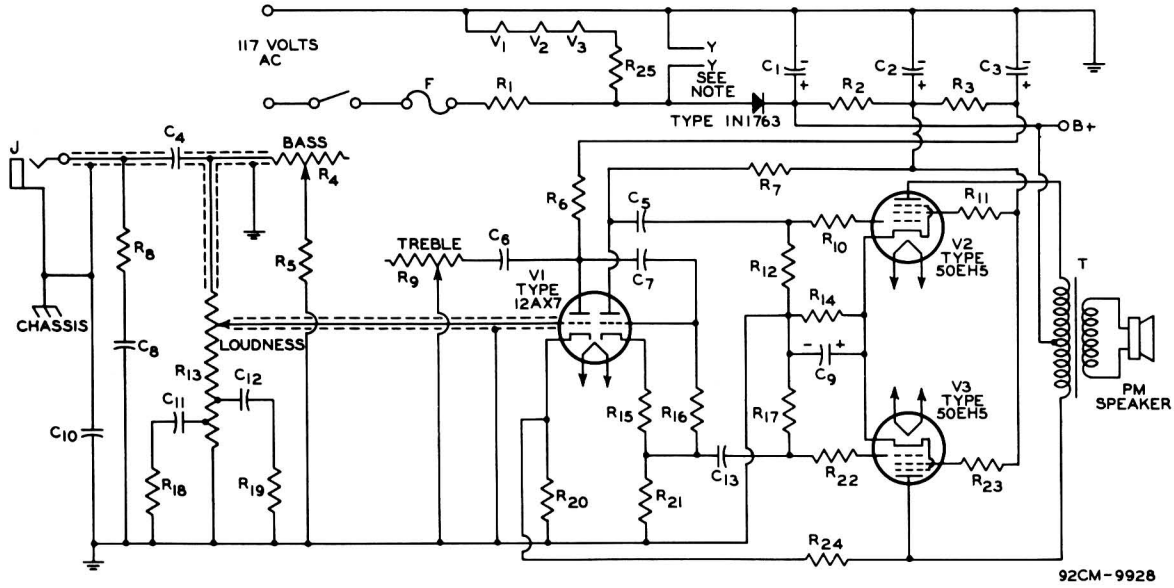
Fig. 1 - Typical Circuit for an Economy Phonograph Amplifier Using An RCA-50EH5.

Economy Phonograph Amplifier

Fig. 1 shows an amplifier circuit suitable for use in low-cost phonographs. With an inexpensive output transformer of the type generally used in these instruments, this amplifier will deliver about 1 watt of audio power to the speaker in the middle of the audio range. If a transformer having increased efficiency is used, an output of about 1.4 watts (maximum rating of the tube) can be approached.

In this circuit, a 50EH5 is driven directly by a crystal pickup, and the input signal is applied effectively between grid No. 1 and cathode. There is no cathode degeneration, therefore, and a cathode bypass capacitor is unnecessary. A resistance capacitance network is used to filter B+ voltage for the screen-grid circuit. Any ripple in the plate circuit appears in phase at both ends of the primary of the output transformer, and, therefore, it is only necessary to make sure that the ripple is small enough not to carry the tube out of its operating plate-voltage rating.

The circuit shown utilizes an RCA-35W4 as a half-wave line rectifier, but it is also possible to utilize a 90-volt, 300-milliampere phonograph motor in series with the heater of a type 25EH5. In this case, a semiconductor diode is required to rectify the ac voltage.



C_1: 250 μf, electrolytic, 150 volts
C_2 C_3: 40 μf, electrolytic, 150 volts
C_4 C_5 C_{13}: 0.01 μf, paper
C_6 C_7: 0.005 μf, paper
C_8: 0.001 μf, paper
C_9: 25 μf, electrolytic, 10 volts
C_{10}: 0.082 μf, paper
C_{11}: 0.03 μf, paper
C_{12}: 0.02 μf, paper
F: Fuse, 3 amperes
J: Input connector, shielded, for high-impedance crystal or ceramic cartridge input
R_1: 5.6 ohms, 10 watts
R_2: 1200 ohms, 2 watts
R_3: 22 ohms
R_4 R_9: Tone control, potentiometer, 2 megohms
R_5: 180,000 ohms
R_6: 220,000 ohms
R_7 R_{21}: 47,000 ohms
R_8: 120,000 ohms
R_{10} R_{22}: 10,000 ohms
R_{11} R_{23}: 56 ohms
R_{12} R_{16} R_{17}: 470,000 ohms
R_{13}: Loudness control, potentiometer, 1.5 megohms, tapped at 250,000 and 500,000 ohms
R_{14}: 68 ohms
R_{15}: 2700 ohms
R_{18}: 12,000 ohms
R_{19}: 100,000 ohms
R_{20}: 5600 ohms
R_{24}: 3.9 megohms
R_{25}: 23 ohms, 1 watt
T: Output transformer, primary impedance 6000 ohms (plate-to-plate), secondary impedance to match speaker voice coil
NOTE: Heater connections (y y) for second channel (not shown) of stereophonic system
All resistors 0.5 watt unless otherwise specified
All capacitors 400 volts unless otherwise specified

Fig. 2 - Circuit Diagram of Low-Cost "Hi-Fi" Amplifier.

Low-Cost "Hi-Fi" Amplifier

Fig. 2 is a schematic diagram of a "hi-fi" amplifier which uses two 50EH5 tubes in class AB_1 push-pull operation. Although it has been designed as a complete stereophonic unit, only one channel has been shown

in the diagram for simplicity (heater connections for both channels are shown). In stereophonic operation, the loudness, treble, and bass controls for both channels are ganged together. The point B+ on the diagram is common to both channels; thus, the switch, fuse, rectifier, filter-input capacitor (C_1), and series-limiting resistor (R_1) serve both units. Starting with resistor R_2, the second-channel power supply is identical to that of the first channel. For safety reasons capacitor C_{10} should be used in only one channel; in the second channel, the lead should be directly grounded.

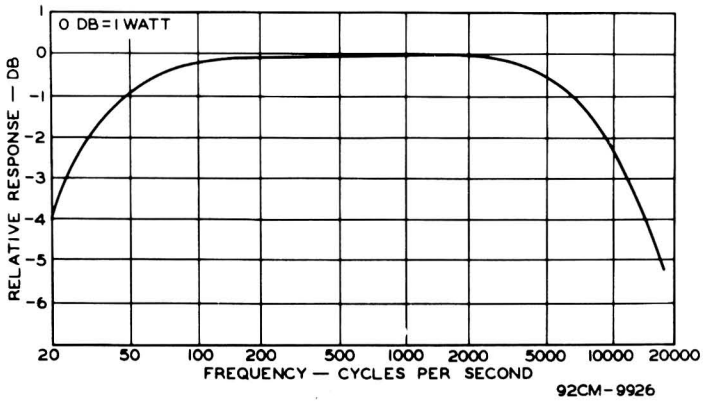


Fig. 3 - Frequency-Response Curve of Low-Cost "Hi-Fi" Amplifier.

The sensitivity of the amplifier is 250 millivolts RMS input for 2.5 watts output. Thus it can be used with stereo phonograph cartridges, which have a somewhat lower output per channel than conventional monaural cartridges, as well as with almost any crystal or ceramic phonograph

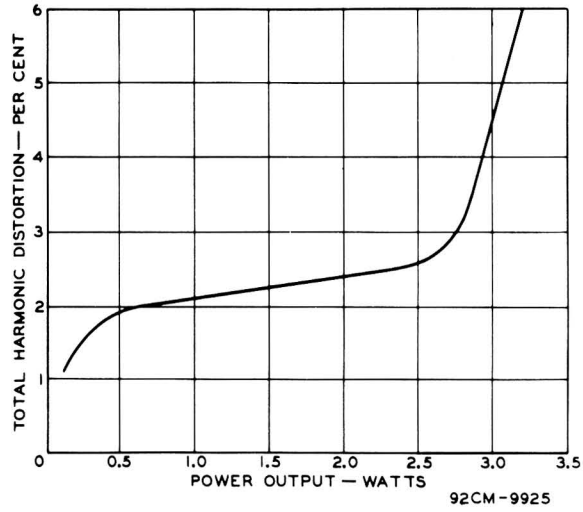


Fig. 4 - Total Harmonic Distortion of "Hi-Fi" Amplifier over its Power Output Range.

cartridge. The relative frequency response of the amplifier is shown in Fig. 3. When used with a low-cost "conventional-type" output transformer, the response is flat within ± 3 db from 25 to 12,000 cycles per second with the tone controls set at the maximum clockwise position. It is possible to extend the high-frequency response further with a transformer of this type if negative feedback obtained from the transformer secondary

is used. In this case, however, the full line voltage would be applied to the speaker terminals and the speaker would have to be completely insulated.

Fig. 4 shows the total harmonic distortion of this amplifier over its power output range. Better frequency response and greater output power can be obtained by the use of a more expensive transformer having reduced losses.

Other Applications

A type 50EH5 can generally be used instead of a type 50C5 in ac-dc table-model radios, with only a change in the value of the cathode resistor, to achieve an increase in gain of approximately 6 decibels. When the screen-grid supply voltage is approximately 90 volts, a cathode resistor of 56 ohms may be used; even smaller values are permissible provided the plate dissipation is kept within ratings.

Table I—General Technical Data For RCA-6EH5, -12EH5, -25EH5, and -50EH5

Electrical:

Heater, for Unipotential Cathode:

	6EH5	*12EH5*	*25EH5*	*50EH5*	
Voltage (AC or DC)	6.3	12.6	25.0	50.0	volts
Current	1.2	0.6	0.3	0.15	amperes
Warm-up Time (Average)	-	11	-	-	seconds

Heater warm-up time is defined as the time required for the voltage across the heater terminals to increase from zero to 0.8 of rated heater voltage.

Direct Interelectrode Capacitance (Approx., without external shield):

Grid No.1 to Plate	0.65	μμf
Grid No.1 to Cathode & Grid No.3, Grid No.2 and Heater	17	μμf
Plate to Cathode & Grid No.3, Grid No.2 and Heater	9	μμf

Mechanical:

Operating Position	Any
Maximum Over-All Length	2-5/8"
Maximum Seated Length	2-3/8"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JEDEC No.E7-1)

Basing	1	2	3	4	5	6	7
	K,G3	G1	H	H	G1	G2	P

AMPLIFIER — Class A_1

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	135	max.	volts
GRID-No.2 (SCREEN-GRID) VOLTAGE	117	max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:			
Positive bias value	0	max.	volts
PLATE DISSIPATION	5.0	max.	watts
GRID-No.2 INPUT	1.75	max.	watts

PEAK HEATER-CATHODE VOLTAGE:

	6-, 25-, & 50EH5	*12EH5*	
Heater negative with respect to cathode	200 max.	300 max.	volts
Heater positive with respect to cathode	200* max.	200* max.	volts

Typical Operation and Characteristics:

Plate-Supply Voltage	110	volts
Grid-No.2 Supply Voltage	115	volts
Peak AF Grid-No.1 Voltage	3	volts
Cathode-Bias Resistor	62	ohms

* The dc component must not exceed 100 volts.

Zero-Signal Plate Current	42		ma
Maximum-Signal Plate Current	42		ma
Zero-Signal Grid-No.2 Current	11.5		ma
Maximum-Signal Grid-No.2 Current	14.5		ma
Plate Resistance (Approx.)	11000		ohms
Transconductance	14600		μmhos
Load Resistance	3000		ohms
Total Harmonic Distortion	7		per cent
Maximum-Signal Power Output	1.4		watts

Maximum Circuit Values (for maximum rated condition):

Grid-No.1-Circuit Resistance:			
For fixed-bias operation	0.1	max.	megohm
For cathode-bias operation	0.5	max.	megohm

Typical Operation and Characteristics in Class AB_1 Push-Pull AF Amplifier Service (values are for 2 tubes)

Plate Supply Voltage	140	volts
Grid-No.2 Supply Voltage	120	volts
Cathode Bias Resistor	68	ohms
Peak AF Grid No.1 to Grid-No.1 Voltage	9.4	volts
Zero-Signal Plate Current	47.0	ma
Maximum-Signal Plate Current	51.0	ma
Zero-Signal Grid-No.2 Current	11.0	ma
Maximum-Signal Grid-No.2 Current	17.7	ma
Effective Load Resistance (Plate to Plate)	6000	ohms
Total Harmonic Distortion	5	per cent
Maximum-Signal Power Output	3.8	watts