

# Resistance-Coupled Amplifiers

**R**ESISTANCE-COUPLED, audio-frequency voltage amplifiers utilize simple components and are capable of providing essentially uniform amplification over a relatively wide frequency range.

## Suitable Tubes

In this section, data are given for over 45 types of tubes suitable for use in resistance-coupled circuits. These types include low- and high- $\mu$  triodes, twin triodes, triode-connected pentodes, and pentodes. The accompanying key to tube types will assist in locating the appropriate data chart.

## Circuit Advantages

For most of the types shown, the data pertain to operation with cathode bias; for all of the pentodes, the data pertain to operation with series screen-grid resistor. The use of a cathode-bias resistor where feasible and a series screen-grid resistor where applicable offers several advantages over fixed-voltage operation.

The advantages are: (1) effects of possible tube differences are minimized; (2) operation over a wide range of plate-supply voltages without appreciable change in gain is feasible; (3) the low frequency at which the amplifier cuts off is easily changed; and (4) tendency toward motorboating is minimized.

## Number of Stages

These advantages can be enhanced by the addition of suitable decoupling filters in the plate supply of each stage of a multi-stage amplifier. With proper filters, three or more amplifier stages can be operated from a single power-supply unit of conventional design with-

Type	Chart No.	Type	Chart No.
3AU6	2	6CG7	8
3AV6	9	6CN7	5
3BC5/		6EU7	9
3CE5	11	6FQ7/	
3CB6	10	6CG7	8
3CF6	11	6SL7GT	5
4AU6	2	6SN7GTB	8
4BQ7A	10	6T8A	5
4BZ7	10	7AU7	3
4CB6	11	8FQ7/	
5BK7A	10	8CG7	8
5BQ7A	10	12AT6	5
5T8	5	12AT7	4
6AB4	4	12AU6	2
6AG5	11	12AU7A	3
6AT6	5	12AV6	9
6AU6A	2	12AX7A	9
6AV6	9	12AY7	1
6BC5	11	12SL7GT	5
6BK7B	10	12SN7GTA	8
6BQ7A	10	20EZ7	9
6BZ7	10	5879P	6
6C4	3	5879T	7
6CB6	11	7025	9
6CB6A	11	7199P	12
6CF6	11	7199T	13

T = Triode Unit or Triode Connection  
P = Pentode Unit or Pentode Connection

## KEY TO CHARTS

out encountering any difficulties due to coupling through the power unit. When decoupling filters are not used, not more than two stages should be operated from a single power-supply unit.

### Symbols Used in Resistance-Coupled Amplifier Charts

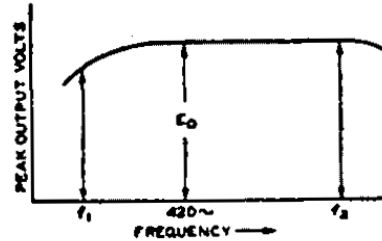
- $C$  = Blocking Capacitor ( $\mu\text{f}$ ).  
 $C_k$  = Cathode Bypass Capacitor ( $\mu\text{f}$ ).  
 $C_{sg}$  = Screen-Grid Bypass Capacitor ( $\mu\text{f}$ ).  
 $E_{bb}$  = Plate-Supply Voltage (volts).  
 Voltage at plate equals plate-supply voltage minus drop in  $R_p$  and  $R_k$ .  
 $R_k$  = Cathode Resistor (ohms).  
 $R_{sg}$  = Screen-Grid Resistor (megohms).  
 $R_g$  = Grid Resistor (megohms) for following stage.  
 $R_p$  = Plate Resistor (megohms).  
 $V.G.$  = Voltage Gain.  
 $E_o$  = Output Voltage (peak volts).  
 This voltage is obtained across  $R_g$  (for following stage) at any frequency within the flat region of the output vs. frequency curve, and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube to the point where its grid starts to draw current.

Note: The listed values for  $E_o$  are the peak output voltages available when the grid is driven from a low-impedance source. The listed values for the cathode resistors are optimum for any signal source. With a high-impedance source, protection against severe distortion and loss of gain due to input loading may be obtained by the use of a coupling capacitor connected directly to the input grid and a high-value resistor connected between the grid and ground.

### General Circuit Considerations

In the discussions which follow, the frequency ( $f_s$ ) is that value at which the high-frequency response begins to fall off. The frequency ( $f_i$ ) is that value at which the low-frequency response drops below a satisfactory value, as discussed below. A variation of 10 per cent in values of resistors and capacitors has only slight effect on perform-

ance. One-half-watt resistors are usually suitable for  $R_{sg}$ ,  $R_g$ ,  $R_p$ , and  $R_k$  resistors. Capacitors  $C$  and  $C_{sg}$  should have a working voltage equal to or greater than  $E_{bb}$ . Capacitor  $C_k$  may have a low working voltage in the order of 10 to 25 volts.



### Triode Amplifier Heater-Cathode Type

Capacitors  $C$  and  $C_k$  have been chosen to give an output voltage equal to  $0.8 E_o$  for a frequency ( $f_i$ ) of 100 cycles. For any other value of  $f_i$ , multiply values of  $C$  and  $C_k$  by  $100/f_i$ . In

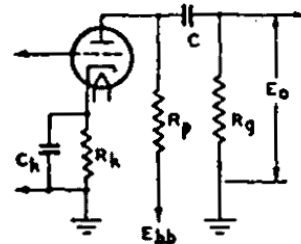


Diagram No. 1

the case of capacitor  $C_k$ , the values shown in the charts are for an amplifier with dc heater excitation; when ac is used, depending on the character of the associated circuit, the gain, and the value of  $f_i$ , it may be necessary to increase the value of  $C_k$  to minimize hum disturbances. It may be desirable to operate the heater at a positive voltage of from 15 to 40 volts with respect to the cathode. The voltage output at  $f_i$  of "n" like stages equals  $(0.8)^n \times E_o$ , where  $E_o$  is the peak output voltage of final stage. For an amplifier of typical construction, the value of  $f_s$  is well above the audio-frequency range for any value of  $R_p$ .

**Pentode Amplifier  
Heater-Cathode Type**

Capacitors  $C$ ,  $C_k$ , and  $C_{gs}$  have been chosen to give an output voltage equal to  $0.7 \times E_o$  for a frequency ( $f_i$ ) of 100 cycles. For any other value of  $f_i$ , multiply values of  $C$ ,  $C_k$ , and  $C_{gs}$  by  $100/f_i$ . In the case of capacitor  $C_k$ , the values shown in the charts are for

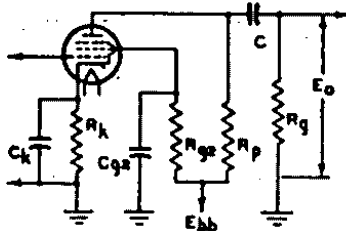


Diagram No. 2

an amplifier with dc heater excitation; when ac is used, depending on the character of the associated circuits, the voltage gain, and the value of  $f_i$ , it may be necessary to increase the value of  $C_k$  to minimize hum disturbances. It may be desirable to operate the heater at a positive voltage of from 15 to 40 volts with respect to the cathode. The voltage output at  $f_i$  for "n" like stages equals  $(0.7)^n \times E_o$ , where  $E_o$  is peak output voltage of final stage. For an amplifier of typical construction, and for  $R_p$  values of 0.1, 0.25, and 0.5 megohm, approximate values of  $f_i$  are 20000, 10000, and 5000 cycles per second, respectively.

1

**12AY7\***  
See Circuit  
Diagram 1

$E_{bb}$	$R_p$	$R_k$	$R_{gs}$	$R_g$	$C_{gs}$	$C_k$	$C$	$E_o^*$	V.E.
90	0.1	0.24	—	1800	—	—	—	13	24
	0.24	0.51	—	3700	—	—	—	14	26
	0.51	1.0	—	7800	—	—	—	16	27
100	0.1	0.24	—	1300	—	—	—	31	27
	0.24	0.51	—	2800	—	—	—	33	29
	0.51	1.0	—	5700	—	—	—	33	30
300	0.1	0.24	—	1200	—	—	—	58	28
	0.24	0.51	—	2300	—	—	—	30	30
	0.51	1.0	—	4800	—	—	—	56	31

\* One triode unit.

\* Peak volts.

^ Coupling capacitors should be selected to give desired frequency response. Cathode resistors should be adequately bypassed.

$E_{b_1}$	$R_p$	$R_s$	$R_{p2}$	$R_L$	$C_{p2}$	$C_L$	$C$	$E_c^*$	V.B.
90	0.22	0.22	0.340	2700	0.057	5.8	0.0081	16	79
	0.22	0.47	0.370	2900	0.050	5.4	0.0055	22	104
	0.22	1.0	0.380	3100	0.050	5.3	0.0034	25	125
	0.47	0.47	1.00	6000	0.027	2.8	0.0042	13	105
	0.47	1.0	1.00	6200	0.023	2.7	0.0027	17	137
	0.47	2.2	1.00	6300	0.027	2.8	0.0019	25	161
	1.0	1.0	1.90	10800	0.017	1.7	0.0025	10	139
	1.0	2.2	2.40	13100	0.017	1.7	0.0017	19	184
180	0.22	0.22	0.520	1340	0.059	8.8	0.0081	31	143
	0.22	0.47	0.520	1390	0.059	8.7	0.0053	43	192
	0.22	1.0	0.520	1420	0.059	8.6	0.0032	48	223
	0.47	0.47	1.05	2700	0.039	5.5	0.0041	34	189
	0.47	1.0	1.15	2880	0.037	5.4	0.0027	43	249
	0.47	2.2	1.20	2960	0.036	5.4	0.0019	50	294
	1.0	1.0	2.40	5500	0.028	3.2	0.0023	33	230
	1.0	2.2	2.70	6000	0.022	2.8	0.0015	40	323
300	0.22	0.22	0.530	780	0.077	13.2	0.0082	53	200
	0.22	0.47	0.540	783	0.077	13.2	0.0053	65	270
	0.22	1.0	0.540	800	0.077	13.1	0.0033	74	316
	0.47	0.47	1.15	1590	0.057	8.4	0.0045	56	275
	0.47	1.0	1.22	1650	0.049	7.4	0.0027	72	357
	0.47	2.2	1.31	1720	0.045	7.2	0.0017	82	418
	1.0	1.0	2.50	3300	0.036	5.3	0.0022	57	352
	1.0	2.2	2.80	3500	0.031	4.2	0.0015	72	466

2

3AU6  
4AU6  
6AU6A  
12AU6

See Circuit  
Diagram 2

90	0.047	0.047	—	1600	—	3.2	0.061	9	10
	0.047	0.1	—	1800	—	2.5	0.033	11	11
	0.047	0.22	—	2000	—	2.0	0.015	14	11
	0.1	0.1	—	3000	—	1.6	0.032	10	11
	0.1	0.22	—	3800	—	1.1	0.015	15	11
	0.1	0.47	—	4500	—	1.0	0.007	18	11
	0.22	0.22	—	6800	—	0.7	0.015	14	11
	0.22	0.47	—	9500	—	0.5	0.0065	20	11
0.22	1.0	—	11500	—	0.43	0.0035	24	11	
180	0.047	0.047	—	920	—	3.9	0.062	20	11
	0.047	0.1	—	1200	—	2.9	0.037	26	12
	0.047	0.22	—	1400	—	2.5	0.016	29	12
	0.1	0.1	—	2000	—	1.9	0.032	24	12
	0.1	0.22	—	2800	—	1.4	0.016	33	12
	0.1	0.47	—	3600	—	1.1	0.007	40	12
	0.22	0.22	—	5300	—	0.8	0.015	31	12
	0.22	0.47	—	8300	—	0.56	0.007	44	12
0.22	1.0	—	10000	—	0.48	0.0035	54	12	
300	0.047	0.047	—	870	—	4.1	0.065	38	12
	0.047	0.1	—	1200	—	3.0	0.034	52	12
	0.047	0.22	—	1500	—	2.4	0.016	68	12
	0.1	0.1	—	1900	—	1.9	0.032	44	12
	0.1	0.22	—	3000	—	1.3	0.016	68	12
	0.1	0.47	—	4000	—	1.1	0.007	80	12
	0.22	0.22	—	5300	—	0.9	0.015	57	12
	0.22	0.47	—	8800	—	0.52	0.007	82	12
0.22	1.0	—	11000	—	0.46	0.0035	92	12	

3

6C4  
7AU7\*  
9AU7\*  
12AU7A\*

See Circuit  
Diagram 1

\* One triode unit.

\* Peak volts.

4

6AB4  
12AT7\*

See Circuit  
Diagram 1

$E_b$	$R_p$	$R_c$	$R_{ca}$	$R_k$	$C_{ca}$	$C_c$	$C$	$E_s^*$	V.R.
90	0.1	0.1	—	2680	—	2.4	0.026	8	24
	0.1	0.22	—	3060	—	2.00	0.014	11	25
	0.1	0.47	—	3390	—	1.84	0.0074	13	28
	0.22	0.22	—	5500	—	1.33	0.0136	10	25
	0.22	0.47	—	6300	—	1.01	0.0067	14	28
	0.22	1.0	—	6930	—	0.92	0.0038	15	28
	0.47	0.47	—	10900	—	0.63	0.007	13	26
	0.47	1.0	—	12500	—	0.52	0.0043	14	28
0.47	2.2	—	13500	—	0.47	0.0031	18	28	
100	0.1	0.1	—	1407	—	3.6	0.029	20	31
	0.1	0.22	—	1674	—	3.0	0.016	28	33
	0.1	0.47	—	1786	—	2.6	0.0083	31	34
	0.22	0.22	—	2890	—	1.75	0.0140	24	33
	0.22	0.47	—	3860	—	1.34	0.0077	35	33
	0.22	1.0	—	4660	—	1.14	0.0047	42	33
	0.47	0.47	—	6960	—	0.83	0.0075	31	31
	0.47	1.0	—	8450	—	0.67	0.0046	39	32
0.47	2.2	—	9600	—	0.55	0.0032	45	32	
300	0.1	0.1	—	974	—	4.0	0.028	37	34
	0.1	0.22	—	1404	—	3.1	0.015	57	34
	0.1	0.47	—	2169	—	2.5	0.0083	78	33
	0.22	0.22	—	2510	—	1.9	0.015	50	33
	0.22	0.47	—	4200	—	1.3	0.0074	78	33
	0.22	1.0	—	4950	—	1.1	0.0046	85	32
	0.47	0.47	—	5700	—	0.90	0.0076	57	33
	0.47	1.0	—	8720	—	0.62	0.0041	81	32
0.47	2.2	—	9700	—	0.57	0.0030	88	32	

5

5T8  
6AT6  
6CN7  
8CN7  
6SL7GT\*  
6T8A  
12AT6  
12SL7GT\*  
19T8

See Circuit  
Diagram 1

90	0.1	0.1	—	4200	—	2.5	0.025	5.4	22
	0.1	0.22	—	4600	—	2.2	0.014	7.5	27
	0.1	0.47	—	4800	—	2.0	0.0065	9.1	30
	0.22	0.22	—	7000	—	1.5	0.013	7.3	30
	0.22	0.47	—	7800	—	1.3	0.007	10	34
	0.22	1.0	—	8100	—	1.1	0.0035	12	37
	0.47	0.47	—	12000	—	0.83	0.006	10	36
	0.47	1.0	—	14000	—	0.7	0.0035	14	39
0.47	2.2	—	15000	—	0.6	0.002	16	41	
100	0.1	0.1	—	1900	—	3.6	0.027	19	30
	0.1	0.22	—	2200	—	3.1	0.014	25	35
	0.1	0.47	—	2500	—	2.8	0.0065	32	37
	0.22	0.22	—	3400	—	2.2	0.014	24	38
	0.22	0.47	—	4100	—	1.7	0.0065	34	42
	0.22	1.0	—	4600	—	1.5	0.0035	38	44
	0.47	0.47	—	6600	—	1.1	0.0065	29	44
	0.47	1.0	—	8100	—	0.9	0.0035	38	46
0.47	2.2	—	9100	—	0.8	0.002	43	47	
300	0.1	0.1	—	1500	—	4.4	0.027	40	34
	0.1	0.22	—	1800	—	3.6	0.014	54	38
	0.1	0.47	—	2100	—	3.0	0.0065	63	41
	0.22	0.22	—	2600	—	2.5	0.013	51	42
	0.22	0.47	—	3200	—	1.9	0.0065	65	46
	0.22	1.0	—	3700	—	1.6	0.0035	77	48
	0.47	0.47	—	5200	—	1.2	0.006	61	48
	0.47	1.0	—	6300	—	1.0	0.0035	74	50
0.47	2.2	—	7200	—	0.9	0.002	85	51	

\* One triode unit.

\* Peak volts.

$E_{bb}$	$R_p$	$R_x$	$R_{x2}$	$R_k$	$C_{x2}$	$C_k$	$C$	$E_o^*$	V.G.
90	0.1	0.1	0.35	1700	0.044	4.6	0.020	13	29
	0.1	0.22	0.35	1700	0.046	4.5	0.012	17	39
	0.1	0.47	0.35	1700	0.047	4.4	0.006	20	47
	0.22	0.22	0.80	3000	0.034	3.2	0.010	15	43
	0.22	0.47	0.80	3000	0.035	3.1	0.005	21	59
	0.22	1.0	0.80	3000	0.036	3.0	0.003	24	67
	0.47	0.47	1.9	7000	0.021	1.8	0.005	21	59
	0.47	1.0	1.9	7000	0.022	1.7	0.003	25	75
	0.47	2.2	1.9	7000	0.023	1.7	0.002	28	87
100	0.1	0.1	0.35	700	0.060	7.4	0.020	24	39
	0.1	0.22	0.35	700	0.062	7.3	0.012	28	56
	0.1	0.47	0.35	700	0.064	7.2	0.006	33	65
	0.22	0.22	0.80	1200	0.045	5.5	0.010	24	65
	0.22	0.47	0.80	1200	0.046	5.3	0.005	31	87
	0.22	1.0	0.80	1200	0.048	5.2	0.003	34	101
	0.47	0.47	1.9	2500	0.033	3.5	0.005	27	98
	0.47	1.0	1.9	2500	0.034	3.4	0.003	32	122
	0.47	2.2	1.9	2500	0.035	3.3	0.002	37	140
300	0.1	0.1	0.35	300	0.075	10.8	0.020	25	51
	0.1	0.22	0.35	300	0.077	10.6	0.012	32	68
	0.1	0.47	0.35	300	0.080	10.5	0.006	35	83
	0.22	0.22	0.80	600	0.056	7.9	0.010	28	81
	0.22	0.47	0.80	600	0.057	7.5	0.005	37	109
	0.22	1.0	0.80	600	0.058	7.4	0.003	41	123
	0.47	0.47	1.3	1200	0.044	5.3	0.005	34	125
	0.47	1.0	1.3	1200	0.046	5.2	0.003	42	152
	0.47	2.2	1.3	1200	0.047	5.1	0.002	48	174
90	0.047	0.047	—	1800	—	2.9	0.060	9	10
	0.047	0.1	—	2100	—	2.4	0.033	12	11
	0.047	0.22	—	2200	—	2.3	0.016	14	21
	0.1	0.1	—	3200	—	1.8	0.027	10	12
	0.1	0.22	—	3900	—	1.3	0.015	13	13
	0.1	0.47	—	4300	—	1.0	0.007	16	13
	0.22	0.22	—	6200	—	0.87	0.015	12	13
	0.22	0.47	—	8100	—	0.53	0.006	16	13
	0.22	1.00	—	9000	—	0.49	0.003	19	14
100	0.047	0.047	—	1200	—	3.5	0.063	21	12
	0.047	0.1	—	1600	—	2.6	0.033	29	13
	0.047	0.22	—	1800	—	2.4	0.016	35	13
	0.1	0.1	—	2200	—	1.9	0.031	26	13
	0.1	0.22	—	2900	—	1.35	0.015	33	14
	0.1	0.47	—	3400	—	1.1	0.007	40	14
	0.22	0.22	—	4500	—	0.92	0.015	28	14
	0.22	0.47	—	6400	—	0.61	0.006	39	14
	0.22	1.00	—	8200	—	0.52	0.003	47	14
300	0.047	0.047	—	1100	—	3.9	0.063	42	13
	0.047	0.1	—	1500	—	2.8	0.033	65	13
	0.047	0.22	—	1700	—	2.5	0.016	71	14
	0.1	0.1	—	2000	—	2.1	0.032	45	15
	0.1	0.22	—	3400	—	1.4	0.015	74	15
	0.1	0.47	—	3700	—	1.1	0.007	83	15
	0.1	0.22	—	4300	—	0.97	0.015	50	15
	0.22	0.47	—	7200	—	0.63	0.007	88	15
	0.22	1.00	—	7400	—	0.63	0.003	94	15

\* Peak volts

6

As Pentode:  
5879

See Circuit  
Diagram 2

7

As Triode:  
5879

See Circuit  
Diagram 1

8

6FQ7/6CG7  
6FQ7  
6SN7GTB\*  
8FQ7/8CG7  
8FQ7\*  
12SN7GTA\*

See Circuit  
Diagram 1

9

3AV6  
4AV6  
6AV6  
6EU7\*  
12AV6  
12AX7A\*  
20EZ7\*  
7025\*

See Circuit  
Diagram 1

$E_{cc}$	$R_p$	$R_r$	$R_{r2}$	$R_k$	$C_{r2}$	$C_k$	$C$	$E_c^*$	V.G.
90	0.047	0.047	—	1870	—	3.1	0.063	14	13
	0.047	0.1	—	2230	—	2.5	0.031	18	14
	0.047	0.22	—	2500	—	2.1	0.016	20	14
	0.1	0.1	—	3370	—	1.8	0.034	15	14
	0.1	0.22	—	4100	—	1.3	0.015	20	14
	0.1	0.47	—	4800	—	1.1	0.006	23	15
	0.22	0.22	—	7000	—	0.80	0.013	16	14
	0.22	0.47	—	9100	—	0.65	0.007	22	14
	0.22	1.00	—	10500	—	0.60	0.004	25	15
100	0.047	0.047	—	1500	—	3.6	0.066	33	14
	0.047	0.1	—	1860	—	2.9	0.055	41	14
	0.047	0.22	—	2160	—	2.2	0.015	47	15
	0.1	0.1	—	2750	—	1.8	0.028	35	15
	0.1	0.22	—	3550	—	1.4	0.015	45	15
	0.1	0.47	—	4140	—	1.3	0.007	51	16
	0.22	0.22	—	5150	—	1.0	0.016	36	16
	0.22	0.47	—	7000	—	0.71	0.007	45	16
	0.22	1.00	—	7800	—	0.61	0.004	51	16
300	0.047	0.047	—	1300	—	3.6	0.061	59	14
	0.047	0.1	—	1580	—	3.0	0.032	73	15
	0.047	0.22	—	1800	—	2.5	0.015	83	16
	0.1	0.1	—	2500	—	1.9	0.031	68	16
	0.1	0.22	—	3130	—	1.4	0.014	82	16
	0.1	0.47	—	3900	—	1.2	0.0065	96	16
	0.22	0.22	—	4800	—	0.95	0.015	68	16
	0.22	0.47	—	6500	—	0.69	0.0065	85	16
	0.22	1.00	—	7800	—	0.58	0.0035	96	16
90	0.1	0.1	—	4400	—	2.7	0.023	5	29
	0.1	0.22	—	4700	—	2.4	0.013	6	35
	0.1	0.47	—	4800	—	2.3	0.007	8	41
	0.22	0.22	—	7000	—	1.6	0.012	6	39
	0.22	0.47	—	7400	—	1.4	0.006	9	45
	0.22	1.0	—	7600	—	1.3	0.003	11	48
	0.47	0.47	—	12000	—	0.9	0.006	9	48
	0.47	1.0	—	13000	—	0.8	0.003	11	52
	0.47	2.2	—	14000	—	0.7	0.002	13	55
100	0.1	0.1	—	1800	—	4.0	0.025	18	40
	0.1	0.22	—	2000	—	3.5	0.013	25	47
	0.1	0.47	—	2200	—	3.1	0.006	32	52
	0.22	0.22	—	3000	—	2.4	0.012	24	53
	0.22	0.47	—	3500	—	2.1	0.006	34	59
	0.22	1.0	—	3900	—	1.8	0.003	39	63
	0.47	0.47	—	5800	—	1.3	0.006	30	62
	0.47	1.0	—	6700	—	1.1	0.003	39	66
	0.47	2.2	—	7400	—	1.0	0.002	45	68
300	0.1	0.1	—	1300	—	4.6	0.027	43	45
	0.1	0.22	—	1500	—	4.0	0.013	57	52
	0.1	0.47	—	1700	—	3.6	0.006	66	57
	0.22	0.22	—	2200	—	3.0	0.013	54	59
	0.22	0.47	—	2800	—	2.3	0.006	69	65
	0.22	1.0	—	3100	—	2.1	0.003	79	68
	0.47	0.47	—	4300	—	1.6	0.006	62	69
	0.47	1.0	—	5200	—	1.3	0.003	77	73
	0.47	2.2	—	5900	—	1.1	0.002	92	75

\* One triode unit. \* Peak volta.

$E_{cc}$	$R_p$	$R_c$	$R_{c2}$	$R_1$	$C_{c2}$	$C_c$	$C$	$E_c^*$	V.G.
90	0.047	0.047	—	1580	—	4.0	0.058	9	18
	0.047	0.10	—	1760	—	3.5	0.032	13	19
	0.047	0.22	—	1820	—	3.0	0.015	16	20
	0.1	0.1	—	2920	—	2.1	0.029	12	19
	0.1	0.22	—	3570	—	1.7	0.015	17	20
	0.1	0.47	—	4020	—	1.4	0.0075	20	20
	0.22	0.22	—	6040	—	0.98	0.0135	16	19
	0.22	0.47	—	7500	—	0.78	0.0075	21	20
	0.22	1.0	—	8800	—	0.63	0.0036	25	20
100	0.047	0.047	—	694	—	6.0	0.062	25	23
	0.047	0.1	—	817	—	4.4	0.032	32	24
	0.047	0.22	—	905	—	4.0	0.0155	35	25
	0.10	0.1	—	1596	—	2.80	0.030	30	23
	0.10	0.22	—	1630	—	2.30	0.0152	32	24
	0.10	0.47	—	1860	—	2.00	0.0073	38	24
	0.22	0.22	—	3950	—	1.24	0.0150	35	22
	0.22	0.47	—	4500	—	0.96	0.0072	41	23
	0.22	1.0	—	5530	—	0.79	0.0038	49	23
200	0.047	0.047	—	438	—	6.70	0.062	38	26
	0.047	0.1	—	542	—	5.50	0.032	48	27
	0.047	0.22	—	644	—	4.30	0.016	57	27
	0.10	0.10	—	1009	—	3.5	0.031	42	25
	0.10	0.22	—	1332	—	2.5	0.015	56	26
	0.10	0.47	—	1609	—	2.1	0.0074	64	25
	0.22	0.22	—	2623	—	1.5	0.015	50	24
	0.22	0.47	—	3900	—	1.1	0.0073	70	24
	0.22	1.0	—	4920	—	0.88	0.0039	84	24
90	0.22	0.22	0.480	3800	0.046	5.5	0.0084	10	89
	0.22	0.47	0.480	3800	0.049	5.5	0.0054	16	114
	0.22	1.0	0.500	4400	0.045	5.3	0.0034	23	128
	0.47	0.47	1.04	7200	0.033	2.9	0.0044	10	111
	0.47	1.0	1.04	7700	0.033	2.8	0.0029	15	133
	0.47	2.2	1.10	8400	0.031	2.6	0.0020	18	152
	1.0	1.0	2.50	16000	0.018	1.4	0.0023	10	118
	1.0	2.2	2.50	18600	0.016	1.2	0.0017	11	139
	100	0.22	0.22	0.550	1600	0.072	9.5	0.0090	30
0.22		0.47	0.620	1800	0.062	8.5	0.0053	36	208
0.22		1.0	0.650	1900	0.062	8.5	0.0034	43	239
0.47		0.47	1.00	3400	0.059	6.0	0.0048	34	183
0.47		1.0	1.00	3500	0.059	6.0	0.0031	41	229
0.47		2.2	1.00	3800	0.059	5.8	0.0020	46	262
1.0		1.0	2.60	7300	0.029	2.7	0.0022	33	227
1.0		2.2	2.60	7400	0.029	2.7	0.0016	38	281
200		0.22	0.22	0.600	980	0.085	13.0	0.0085	51
	0.22	0.47	0.680	1090	0.084	12.0	0.0055	64	288
	0.22	1.0	0.700	1150	0.081	11.0	0.0033	74	334
	0.47	0.47	1.25	2000	0.064	7.9	0.0045	52	285
	0.47	1.0	1.34	2150	0.061	7.6	0.0029	67	363
	0.47	2.2	1.53	2350	0.057	7.1	0.0019	79	416
	1.0	1.0	2.60	4000	0.044	5.2	0.0023	51	334
	1.0	2.2	3.00	4700	0.038	4.3	0.0015	69	427

10

4BQ7A\*  
4BZ7\*  
5BK7A\*  
5BQ7A\*  
6BK7B\*  
6BQ7A\*  
6BZ7\*

See Circuit Diagram 1

11

3BC5/3CE5  
3CB6  
3CF6  
4CB6  
6AG5  
6BC5  
6CB6  
6CB6A  
6CF6

See Circuit Diagram 2

\* One triode unit.

\* Peak volts.

12

7199

Pentode Unit

See Circuit Diagram 2

13

7199

Triode Unit

See Circuit Diagram 1

$E_{bb}$	$R_p$	$R_c$	$R_{gr}$	$R_k$	$C_{gr}$	$C_k$	$C$	$E_c^*$	V.E.
90	0.22	0.22	0.560	3700	0.046	4.50	0.0090	12	73
	0.22	0.47	0.600	3900	0.043	4.30	0.0055	17	95
	0.22	1.0	0.640	4200	0.039	4.00	0.0033	19	109
	0.47	0.47	0.870	6000	0.036	2.70	0.0046	16	95
	0.47	1.0	0.980	6700	0.044	3.00	0.0030	22	113
	0.47	2.2	1.00	6700	0.043	2.80	0.0020	25	131
	1.0	1.0	2.00	12200	0.021	1.44	0.0028	15	119
	1.0	2.2	2.20	12800	0.024	1.74	0.0016	21	167
100	0.22	0.22	0.530	1570	0.069	7.50	0.0088	32	82
	0.22	0.47	0.600	1730	0.064	7.40	0.0064	38	164
	0.22	1.0	0.650	1820	0.061	7.30	0.0034	45	190
	0.47	0.47	1.12	3200	0.053	5.30	0.0046	35	147
	0.47	1.0	1.40	3500	0.042	5.10	0.0028	40	209
	0.47	2.2	1.57	3740	0.040	5.40	0.0019	45	250
	1.0	1.0	2.50	6500	0.039	2.80	0.0024	34	179
	1.0	2.2	3.40	7500	0.026	2.30	0.0015	39	277
300	0.22	0.22	0.600	9200	0.086	11.2	0.0085	52	182
	0.22	0.47	0.670	1010	0.076	10.5	0.0052	66	236
	0.22	1.0	0.720	1100	0.076	10.0	0.0033	77	257
	0.47	0.47	1.25	1950	0.060	7.0	0.0044	41	221
	0.47	1.0	1.43	3210	0.053	6.4	0.0027	72	296
	0.47	2.2	1.45	2200	0.055	6.3	0.0019	82	345
	1.0	1.0	3.00	4100	0.040	4.2	0.0022	57	295
	1.0	2.2	3.30	4340	0.037	3.6	0.0016	74	378
90	0.047	0.047	—	1292	—	3.3	0.060	8	12
	0.047	0.1	—	1401	—	2.8	0.032	10	13
	0.047	0.22	—	1470	—	2.4	0.016	11	13
	0.10	0.1	—	2630	—	1.60	0.029	9	13
	0.10	0.22	—	3090	—	1.24	0.015	12	13
	0.10	0.47	—	3440	—	1.10	0.008	14	14
	0.22	0.22	—	6550	—	0.70	0.015	12	12
	0.22	0.47	—	8270	—	0.51	0.0077	16	12
	0.22	1.0	—	9130	—	0.44	0.0045	18	12
	100	0.047	0.047	—	723	—	4.0	0.061	16
0.047		0.1	—	836	—	3.5	0.032	20	14
0.047		0.22	—	948	—	2.9	0.016	24	15
0.10		0.1	—	1543	—	2.0	0.031	17	14
0.10		0.22	—	2002	—	1.6	0.016	24	14
0.10		0.47	—	2522	—	1.2	0.0082	30	13
0.22		0.22	—	4390	—	0.79	0.015	24	13
0.22		0.47	—	6122	—	0.57	0.0078	33	12
0.22		1.0	—	8060	—	0.47	0.0046	41	12
300		0.047	0.047	—	534	—	4.0	0.061	27
	0.047	0.1	—	726	—	3.6	0.031	38	15
	0.047	0.22	—	840	—	3.0	0.015	44	15
	0.10	0.1	—	1117	—	2.3	0.031	26	15
	0.10	0.22	—	1613	—	1.7	0.0155	41	14
	0.10	0.47	—	2043	—	1.31	0.0078	51	14
	0.22	0.22	—	3133	—	0.93	0.015	36	13
	0.22	0.47	—	4480	—	0.69	0.0079	51	13
	0.22	1.0	—	4930	—	0.56	0.0045	55	13

\* Peak volts.