

**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 48 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	6FQ7/	
3AV6	9	6CG7	8
3BC5/		6SL7GT	5
3CE5	11	6SN7GTB	8
3CB6/		6T8A	5
3CF6	11	7AU7	3
4AU6	2	8CN7	5
4AV6	9	8FQ7/	
4BQ7A/		8CG7	8
4BZ7	10	9AU7	3
4CB6	11	12AT6	5
5BK7A	10	12AT7/	
		ECC81	4
5BQ7A	10	12AU6	2
5T8	5	12AU7A/	
6AB4	4	ECC82	3
6AG5	11	12AV6	9
6AT6	5	12AX7A/	
6AU6A	2	ECC83	9
6AV6	9	12AY7	1
6BC5/		12FQ7	8
6CE5	11	12SL7GT	5
6BK7B	10	12SN7GTA	8
6BQ7A/		19T8	5
6BZ7/		20EZ7	9
6BS8	10		
6C4	3	5879P	6
6CB6A/		5879T	7
6CF6	11	7025	9
6CN7	5	7199P	12
6EU7	9	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

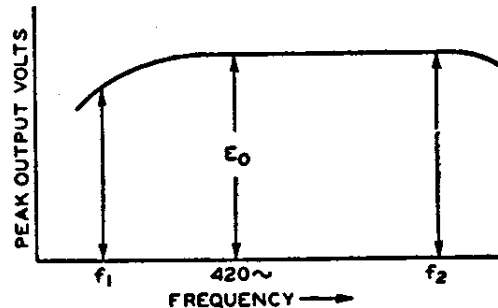
- $C$  = Blocking Capacitor ( $\mu\text{F}$ ).  
 $C_k$  = Cathode Bypass Capacitor ( $\mu\text{F}$ ).  
 $C_{gs}$  = Screen-Grid Bypass Capacitor ( $\mu\text{f}$ ).  
 $E_{bb}$  = Plate-Supply Voltage (volts).  
 Voltage at plate equals plate-supply voltage minus drop in  $R_p$  and  $R_k$ .  
 $R_k$  = Cathode Resistor (ohms).  
 $R_{gs}$  = 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 ( $f_2$ ) is that value at which the high-frequency response begins to fall off. The frequency ( $f_1$ ) is that value at which the low-frequency response

ance. One-half-watt resistors are usually suitable for  $R_{gs}$ ,  $R_g$ ,  $R_p$ , and  $R_k$  resistors. Capacitors  $C$  and  $C_{gs}$  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 ( $f_1$ ) of 100 Hz. For any other value of  $f_1$ , multiply values of  $C$  and  $C_k$  by  $100/f_1$ . In

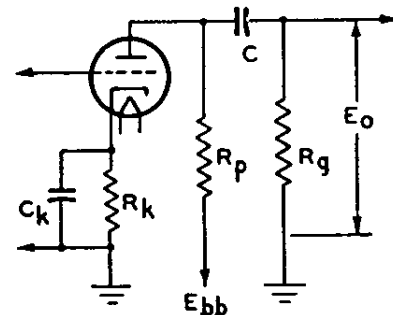


Diagram No. 1

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  $f_1$ , 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  $f_1$  of "n" like stages equals  $(0.8)^n \times E_o$ , where  $E_o$  is the peak output voltage of the first stage. For an amplifier of typical

In the discussions which follow, the frequency ( $f_2$ ) is that value at which the high-frequency response begins to fall off. The frequency ( $f_1$ ) 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-

to operate the heater at a positive voltage of from 15 to 40 volts with respect to the cathode. The voltage output at  $f_1$  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  $f_2$  is well above the audio-frequency range for any value of  $R_p$ .

## RESISTANCE-COUPLED AMPLIFIERS

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### Pentode Amplifier

#### Heater-Cathode Type

Capacitors  $C$ ,  $C_k$ , and  $C_{g2}$  have been chosen to give an output voltage equal to  $0.7 \times E_o$  for a frequency ( $f_1$ ) of 100 cycles. For any other value of  $f_1$ , multiply values of  $C$ ,  $C_k$ , and  $C_{g2}$  by  $100/f_1$ . In the case of capacitor  $C_k$ , the values shown in the charts are for

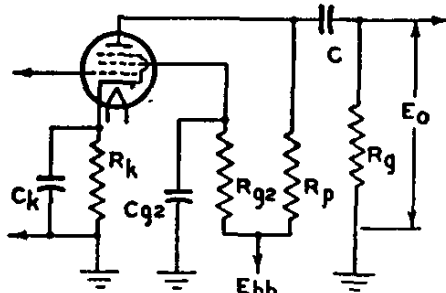


Diagram No. 2

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  $f_1$ , 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  $f_1$  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  $f_2$  are 20000, 10000, and 5000 Hz, respectively.

$E_{bb}$	$R_p$	$R_k$	$R_{g2}$	$R_k$	$C_{g2}$	$C_k$	$C$	$E_o^*$	V.G.
<b>90</b>	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
<b>180</b>	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
<b>300</b>	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

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Pentode  
Unit

See Circuit  
Diagram 2

<b>90</b>	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
<b>180</b>	0.047	0.047	—	723	—	4.0	0.061	16	14
	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
<b>300</b>	0.047	0.047	—	534	—	4.0	0.061	27	15
	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

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Triode  
Unit

See Circuit  
Diagram 1

\* Peak volts.