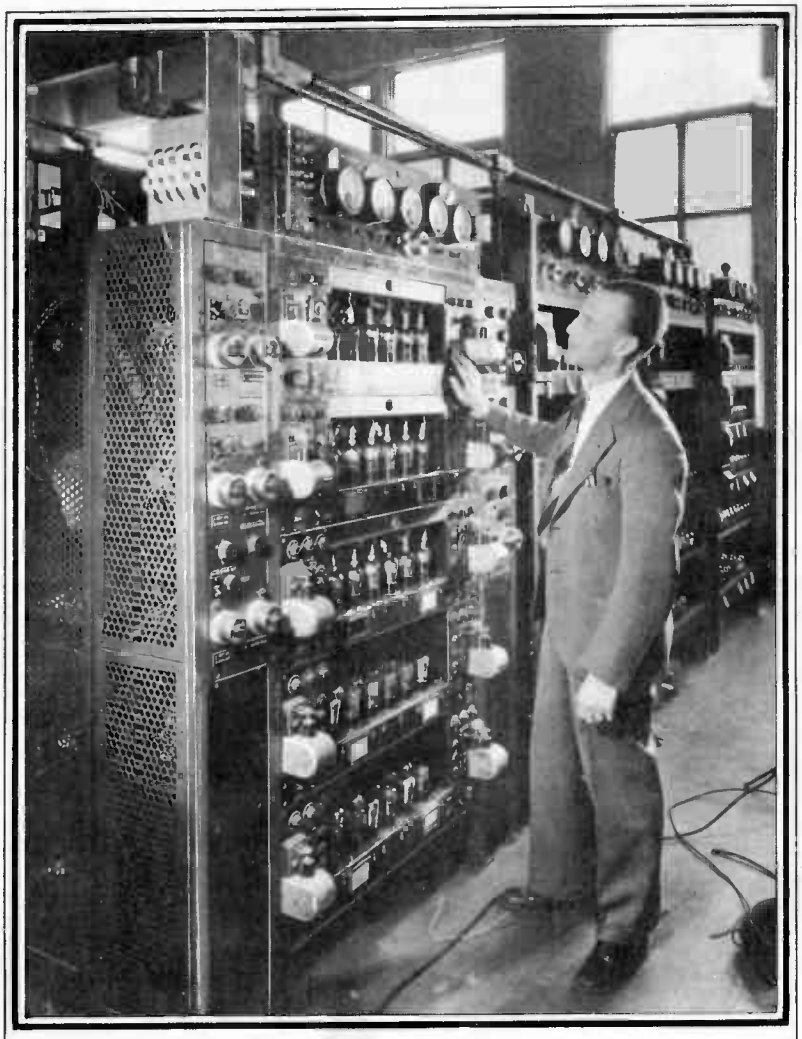
RCA INSTITUTES INC

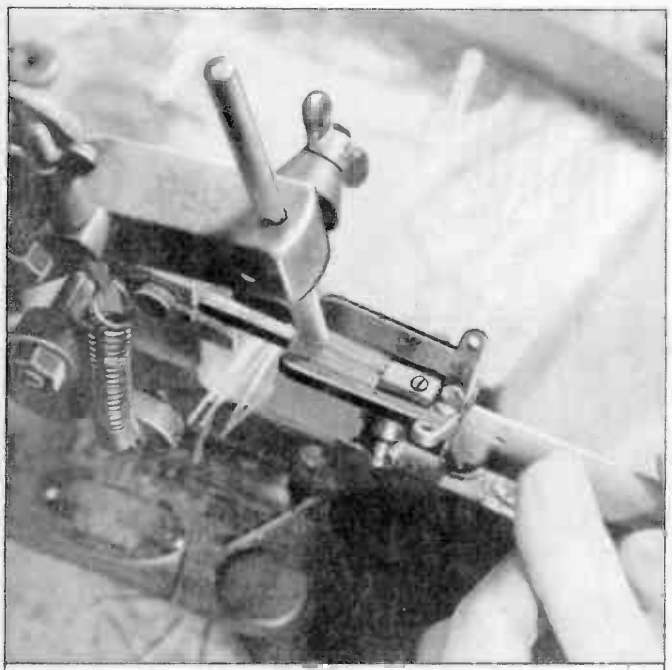


UNIVERSAL RACK FOR TESTING ALL TYPE RECEIVING TUBES UNDER VARIOUS VOLTAGE CONDITIONS

RECEIVING VACUUM TUBES

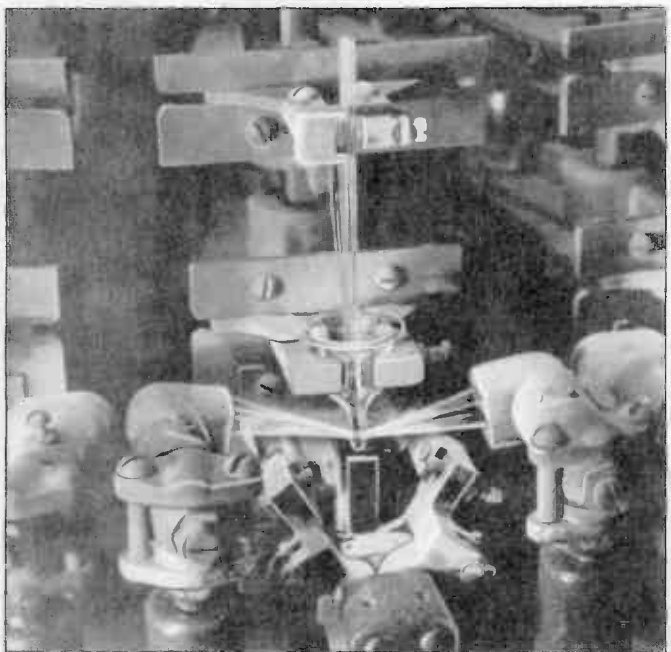
VOL. 13 # 1

DEWEY DECIMAL CLASSIFICATION R130

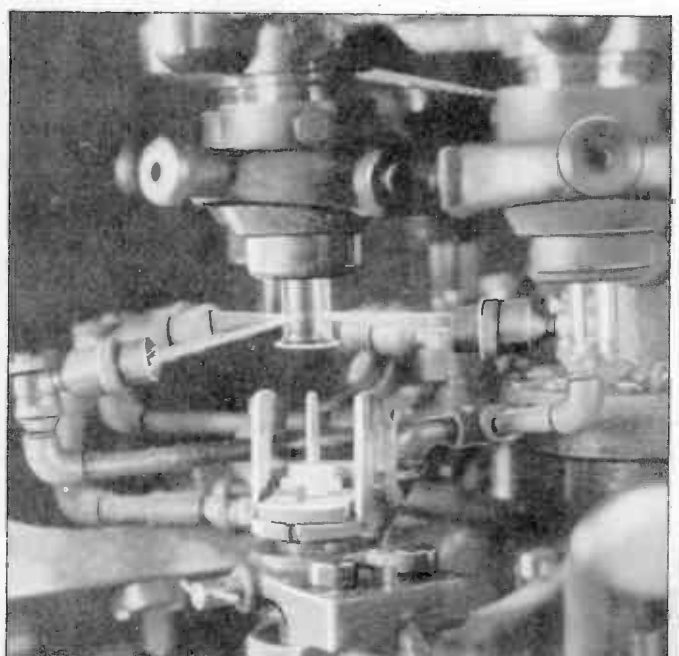


FORMING THE SCREEN BY ELECTRICAL WELD

IN SOME TUBES THERE ARE AS MANY AS 52 SPOT WELDS



THE STEM JUST AFTER THE MOLTEN GLASS HAS BEEN PINCHED TOGETHER, ENCASING THE LEAD-IN WIRES



AUTOMATIC, PRESSURE MEASURED GAS FLAMES HELP SHAPE THE FLARE OF THE GLASS STEM OF THE TUBE

VOL. 13 #1 sheet 1 (47-A)

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RECEIVING VACUUM TUBES

POWER OUTPUT PENTODE.....TYPE 247 FOR A-C SETS

Considerable interest exists at present in the pentode tube. The pentode, as its name implies, is a five-electrode tube. The outstanding characteristics of the tube are its high amplification factor, high internal resistance and high mutual conductance. These properties are obtained by the use of two electrodes or grids which are arranged in the tube as shown in Figure 1. In the illustration, the electrodes are identified as follows: F represents the filament; G1 is a conventional control grid; G2 is a grid or screen which is maintained at a high positive potential and serves to reduce the effects of "space charge" around the filament and to flatten out the plate current-plate voltage characteristics; and G3 is a grid or screen which is usually connected internally to the filament or cathode of the tube and is therefore maintained at essentially ground potential.

A very important function of grid G3 is to suppress or prevent the flow of electrons (liberated by secondary emission effects) from the plate P. The secondary emission is caused by the tremendous impact of electrons on the plate which liberates other electrons from the plate. These new secondary electrons would tend to move toward the screen grid because of its high positive potential were it not for the presence of the extra grid which is operated at the same potential as the filament and therefore does not exert an attraction for electrons. Hence, the secondary electrons return to the plate and together with the regular electrons that collect on the plate increase the flow of electrons in the plate circuit.

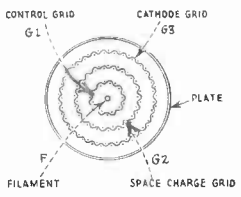

Figure 1

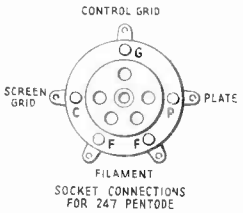

Figure 1-A

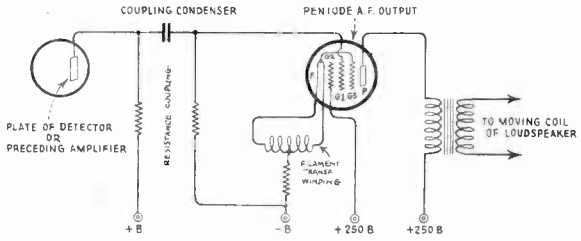

Figure 2

A schematic connection for the pentode tube is shown in Figure 2. A pentode is thus essentially a power amplifier tube having high mutual conductance and high "power sensitivity," that is, relatively small input voltage is required to control rather high power in its plate circuit. This tube employs a coated filament designed primarily for a-c operation. The filament should be operated at its normal rated

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voltage of 2.5 volts at the normal design line voltage. The socket required by the pentode is of the standard UY type and should be mounted to hold the tube in a vertical position. Grid bias for the 247 may be obtained either from a fixed voltage source or by automatic self-biasing from a resistor in the cathode circuit.

POWER OUTPUT PENTODE - TYPE 247

Tentative Rating and Characteristics

Filament Voltage	2.5	volts
Filament Current	1.5	amperes
Plate Voltage, Recommended	250	volts
Screen Voltage, Recommended and Maximum	250	volts
Grid Voltage	-16.5	volts
Plate Current	32	milliamperes
Screen Current	7.5	milliamperes
Plate Resistance	38,000	ohms
Mutual Conductance	2,500	micromhos
Load Resistance, Approximate	7,000	ohms
Power Output	2.5	watts
Base and Socket		UY

The pentode has possible applications (with different designs) in both the audio-frequency and radio-frequency amplifier circuits of broadcast receivers. When used as a radio-frequency amplifier the tube has the form of a screen-grid tube in which an additional grid is placed between the filament (cathode) and usual control grid. This additional grid serves to reduce the effects of "space charge" around the filament (cathode) and results in a tube having higher mutual conductance than screen-grid tubes now available. The theoretical advantage sought in tubes of this kind in the r-f stage of a receiver is that, because of their greater amplification factor, the total number of tubes used might be reduced. However, present broadcast conditions and selectivity requirements are such that a reduction in the number of tuned r-f stages is not permissible and therefore, if one tube is used per stage, as other practical considerations require be done, the total number of radio-frequency tubes cannot be reduced. Also, if too much amplification per stage is attempted it will likely result in a circuit whose operation is critical and unstable. The new 247 pentode has been developed for use as an audio-frequency output or last stage amplifier tube in a-c receivers designed for it. Due to its higher undistorted output (U.P.O.) this tube takes the place of the 245 in the latest model sets.

PENTODE FOR BATTERY-OPERATED RECEIVERS - TYPE 233

The power amplifier pentode, type 233, has been developed for use in the power output stage of battery-operated receivers designed especially for it. The filament employed in this new tube is of the coated type and its low filament current drain makes this tube particularly applicable for use in combination with the 230 and 232 when one or both of these types are incorporated in sets where economy of filament current is an important factor.

As in the case of other pentode tubes the large audio output of the 233 with relatively small input signal voltages on the grid is made possible by the addition of a "suppressor" grid between the screen and the plate.

POWER OUTPUT PENTODE - TYPE 233

Preliminary Ratings and Characteristics

Filament Voltage	2.0	volts
Filament Current	0.260	ampere
Plate Voltage	135	volts
Screen Voltage	135	volts
Grid Voltage	-13.5	volts
Plate Current	14	milliamperes
Screen Current	3	milliamperes
Plate Resistance	45,000	ohms
Mutual Conductance	1,400	micromhos
Amplification Factor	63	
Load Resistance	7,500	ohms
Undistorted Power Output	650	milliwatts
Base and Socket		UY

As we have already explained the suppressor is connected inside the tube to one end of the filament, and is effective in practically eliminating the secondary emission effects which limit the power output from four-electrode screen-grid type tubes.

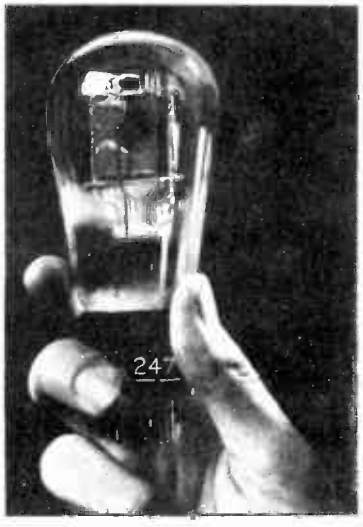

Figure 3

Figure 4

The tube illustrated in Figure 3 is the new 247 pentode which has been developed for use in the audio output stage of a-c receivers designed for it. The three tubes in the photograph in Figure 4 are the new series of indirectly heated cathode tubes designed especially for automobile receivers.

POWER AMPLIFIER TUBE - TYPE 171-A

The 171-A type vacuum tube is a power amplifier for supplying large undistorted power output to a loudspeaker. It is intended for use in the last stage of an audio-frequency amplifier. This tube is designed for use with the standard UX socket, which should be mounted so as to hold the tube in a vertical position. The socket should make firm contact on the filament prongs to minimize contact resistance. The socket connections are given in Figure 5.

The filament of the 171-A type may be operated from a storage battery or from the a-c line through a step-down transformer. In either case the voltage applied to the filament terminals should be the rated value of 5.0 volts. When operated at this voltage, the coated filament will glow at only a dull red color. If alternating current is used to operate the filament, the leads should be of twisted pair and should be kept away from other parts of the circuit where possible. It is recommended that the power be turned off before any tube is removed from the receiver so that excessive voltage will not be applied to the filaments, or heaters, of the remaining tubes.

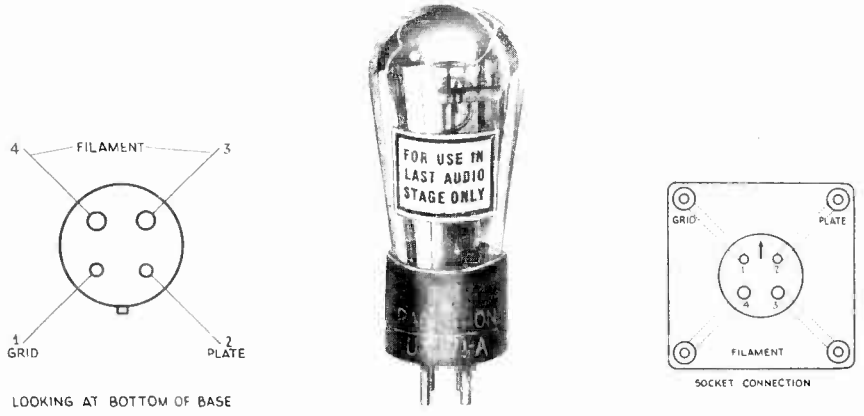

Figure 5

A-C LINE VOLTAGE. If the source of e.m.f. for operating the filament of the 171-A type is the a-c power line, precautions should be exercised to insure that the line voltage is the same as that for which the primary of the filament transformer is designed. To be sure that such is the case, the supply line voltage should be determined with a high grade a-c voltmeter having a range of 0 to 150 volts. If the line voltage measures in excess of that for which the transformer is designed, a series resistor should be inserted in the supply line to reduce the line voltage to the rated value of the transformer primary. Unless this is done, the excess input voltage will cause proportionately excessive voltage to be applied to the filament. Remember that any radio vacuum tube may be damaged or made inoperative by excessive operating voltage.

If the line voltage is consistently so much below that for which the primary of the transformer is designed as to make it impossible

to ever obtain a filament voltage of 5.0 volts, it may be necessary to install a booster transformer between the a-c outlet and the transformer primary. Before such a transformer is installed, the a-c line fluctuations should be carefully measured. Many radio sets are equipped with a line voltage switch which permits adjustment of the power transformer primary to the line voltage. When this switch is properly adjusted, the series resistor or booster transformer mentioned above is seldom required.

CIRCUIT REQUIREMENTS. When the filament is operated from a d-c source, the grid and plate returns should be made to the negative filament terminal. When a-c is used on the filament, the plate and grid returns should be brought either to a mid-tapped resistor of from 20 to 40 ohms across the filament windings, or to the mid-tap of the filament winding itself.

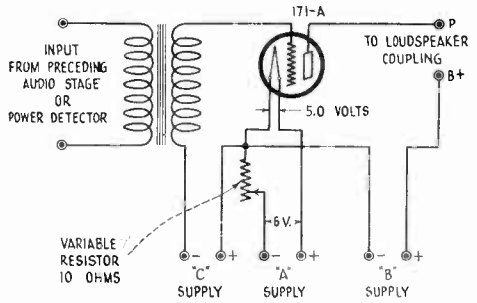

Figure 6

A negative grid bias, as shown in the table of "OPERATING VOLTAGES" on the following page, should always be used with this tube to prevent distortion and overloading. This bias may be obtained by means of a "C" battery or by means of the voltage drop through a resistor in the plate return lead, as shown in Figures 6 and 7 respectively. These diagrams show typical audio power amplifier circuits. The proper value of the resistor is 2150 ohms when 180 volts are used on the plate; 1700 ohms when 135 volts are used; and 1600 ohms when 90 volts are applied to the plate.

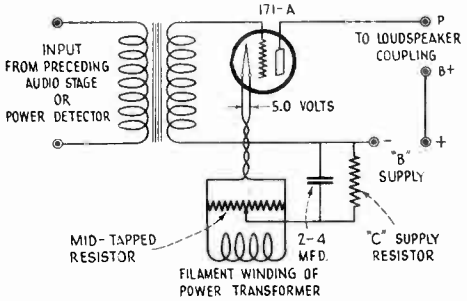

Figure 7

Either an output transformer or a choke coil and condenser should be used, as shown in Figure 8, to keep the high plate current of the 171-A from the windings of the loudspeaker driving unit.

Figure 8

In regard to the operating voltages and characteristics of this tube it can be said that the value of 180 volts with its corresponding grid voltage need be used only in cases where there is a sufficient signal to secure the full grid swing and where the maximum power of the tube is desired. Where maximum output is not essential, the use of either of the lower values of plate voltage with their respective grid bias voltages, is recommended. It should be noted that high plate voltage does not of itself produce appreciably greater volume. What it does is to allow the use of a larger negative grid bias and this in turn permits the application of a larger signal voltage to the grid. The combined result gives higher volume without distortion when the volume control of the receiver is advanced.

POWER AMPLIFIER TUBE - TYPE 171-A

Rating and Data

Filament Voltage			5.0	volts a-c or d-c
Filament Current			.25	amperes
Plate Voltage	90	135	180	volts maximum
Grid Voltage (C-Bias)*	19	29.5	43	volts
Peak Grid Swing	16.5	27	40.5	volts
Plate Current	12	17.5	20	milliamperes
Plate Resistance	2250	1960	1850	ohms
Amplification Factor	3	3	3	
Mutual Conductance	1350	1520	1620	micromhos
Undistorted Power Output	125	370	700	milliwatts
Approximate Direct Inter-Electrode Capacitances				
Grid to Plate			8.2	mmf.
Grid to Filament			4.5	mmf.
Plate to Filament			2.5	mmf.

*Values of grid voltage are given with respect to the mid-point of the filament operated on a-c. If the filament is d-c operated, each given value of grid voltage should be decreased by 2.5 volts and be referred to the negative end of the filament.

If it is desired to obtain, without an increase in plate voltage, more power output than one tube of this type will deliver then two tubes may be operated in parallel or in push-pull. The parallel connection permits increased power output without any increase in the signal applied to the power stage, while the push-pull connection for maximum power output requires that the input signal to the power stage be doubled, but it provides more freedom from distortion.

POWER AMPLIFIER - TYPE 245

The 245 vacuum tube is a power amplifier for supplying large undistorted output to a loudspeaker. It is intended for use in the last stage of an audio-frequency amplifier, in a socket whose filament voltage is 2.5 volts. It should be borne in mind that a 245 tube is not interchangeable with a 171-A tube or any other power amplifier tube.

The socket connections for this tube are like the standard UY socket. It is important to locate a tube of this kind in a set to allow sufficient natural circulation to prevent overheating. The filament may be operated from a storage battery or from the a-c line through a step-down transformer. In either case the voltage to the filament terminals should be the rated value of 2.5 volts. Concerning low resistance connections in the filament circuit splices and about turning the power off before any tube is removed to prevent excessive voltage from being applied to the filaments or heaters of the remaining tubes, the same conditions hold for the 245 as for the 226.

CIRCUIT REQUIREMENTS. To prevent distortion and overloading, negative grid bias as shown in the table of "OPERATING VOLTAGES," should always be used with this tube. It is strongly recommended that this bias be obtained by means of the voltage drop through a resistor in the plate return lead. See Figures 9 and 10 for the general arrangement of circuits utilizing a-c or d-c filament voltage supply.

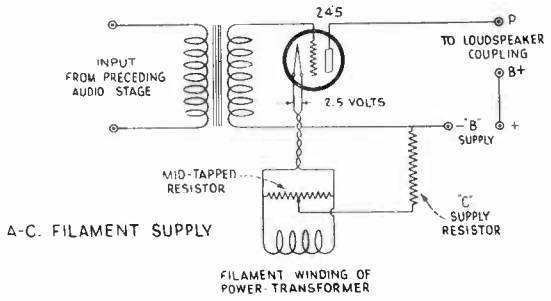

Figure 9

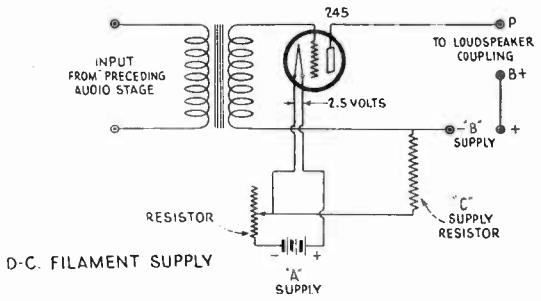

Figure 10

The proper value of a resistor in the plate return lead should be 1550 ohms when 250 volts are used on the plate, or 1350 ohms when 180 volts are used. This method of obtaining the bias must be used in any amplifier circuit where grid leaks are used. In such a circuit a grid leak having a resistance of greater than 1.0 megohm should not be used. When the filament is operated from a d-c source, the grid and plate returns should be made to the negative filament terminals. When a-c is used on the filament, the plate and grid returns should be brought to (1) a mid-tapped resistor of from 20 to 40 ohms across the filament windings, or (2) the mid-tap of the filament winding itself.

Either an output transformer or a choke coil and condenser should be used to keep the high plate current of the 245 from the windings of the loudspeaker driving unit. This was previously referred to in Figure 8.

POWER AMPLIFIER - TYPE 245

Rating and Data

Filament Voltage		2.5	volts a-c or d-c
Filament Current		1.5	amperes
Plate Voltage	180	250	volts (maximum)
Grid Voltage (C-Bias)	-33	-50	volts
Peak Grid Swing	33	50	volts
Plate Current	26	32	milliamperes
Plate Resistance	1950	1900	ohms
Amplification Constant	3.5	3.5	
Mutual Conductance	1800	1850	micromhos
Undistorted Power Output	780	1600	milliwatts

If it is desired to obtain more power output than one 245 tube will deliver then two 245 tubes may be operated in parallel or push-pull. The parallel connection permits increased power output without any increase in the signal applied to the power stage, while the push-pull connection for maximum power output requires that the input signal to the power stage be doubled, as previously explained.

The value of 250 volts with its negative grid bias of 50 volts need be used only in those cases where there is a sufficient signal to secure the full grid swing and where the maximum power output of a 245 tube is desired. Where maximum output is not essential, the lower value of 180 volts with a negative grid bias of 33 volts, is recommended. As stated before, high plate voltage does not of itself produce appreciably greater volume but it allows the use of a larger negative grid bias and this in turn permits the application of a larger signal to the grid. Consequently, the combined result gives higher volume without distortion when the volume control of a given receiver is advanced.

SCREEN GRID R-F AMPLIFIER - TYPE 222

The 222 vacuum tube is a screen-grid amplifier recommended for use primarily as a radio-frequency amplifier in carefully shielded circuits especially designed for it. It may also be effectively used as a space-charge grid tube or as a double-grid tube in special circuits. This tube is designed for use with the standard UX socket, the socket connections being given in Figure 11. The connection for the control grid is made to the metal cap at the top of the tube.

The voltage applied to the filament terminals of the 222 should not exceed the rated value of 3.3 volts. It may be supplied by either dry-cells so connected as to give 4.5 volts or by a storage battery of 6 volts, depending upon whether 3.3 volt or 5.0 volt filament tubes are used in the other stages of the radio receivers.

When the 222 type is to be used in connection with storage battery tubes, for example tubes such as a 201-A, 112-A, and so on, then each 222 should have a 15 ohm resistor connected in series with its negative filament lead with the resistor tapped at 12 ohms. The resistor and filament may then be connected directly in parallel with the 5 volt filaments of the other tubes and operated from the same common rheostat. This connection is shown in Figure 12.

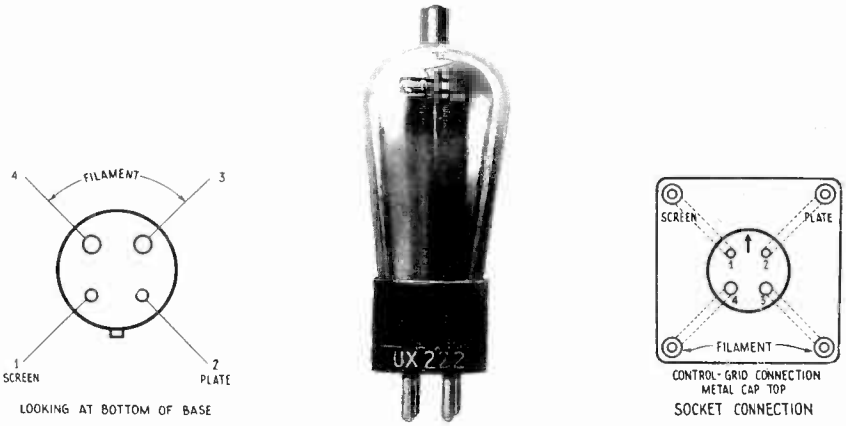

Figure 11

Or, if dry-cell tubes, such as a 199 and 120, are used the filament of the 222 may be connected directly in parallel with the filaments of the other tubes and operated from the same common rheostat. This arrangement is given in Figure 13. It is recommended that both the filament and plate voltage be disconnected before any tube is inserted in or removed from its socket as we suggested before.

HOW TO OBTAIN SCREEN VOLTAGE. The positive voltage for the screen should be obtained from a tap on the plate battery or from a tap so located on the B - supply device, such as a voltage divider for example, as to definitely give the required screen voltage. Never attempt to obtain the screen voltage by connecting the screen through a series resistor to a high plate voltage source, such as that of the power amplifier tube for instance. Such a series resistor connection will not ir general be satisfactory for screen voltage supply because of the considerable variation in screen current of different tubes.

The screen voltage obtained from a definite voltage tap on the B - battery or the B - supply device may be made variable between 0 and 45 volts by the use of a potentiometer connected as shown in Figures 12 and 13 which are typical screen grid r-f amplifier circuits. As the voltage applied to the screen is reduced by adjustment of the potentiometer, the mutual conductance of the 222 tube is decreased with consequent reduction in volume. The potentiometer method, therefore, makes a suitable volume control for the receiver in which it is used.

It should be noted that when the potentiometer method of volume control is used with a "B" battery source of screen potential, precautions should be taken to provide for opening the screen grid circuit connection to the "B" battery when the radio set is not in use as indicated at X in Figure 13. If this precaution is not observed, current will continue to flow through the potentiometer and shorten the life of the battery.

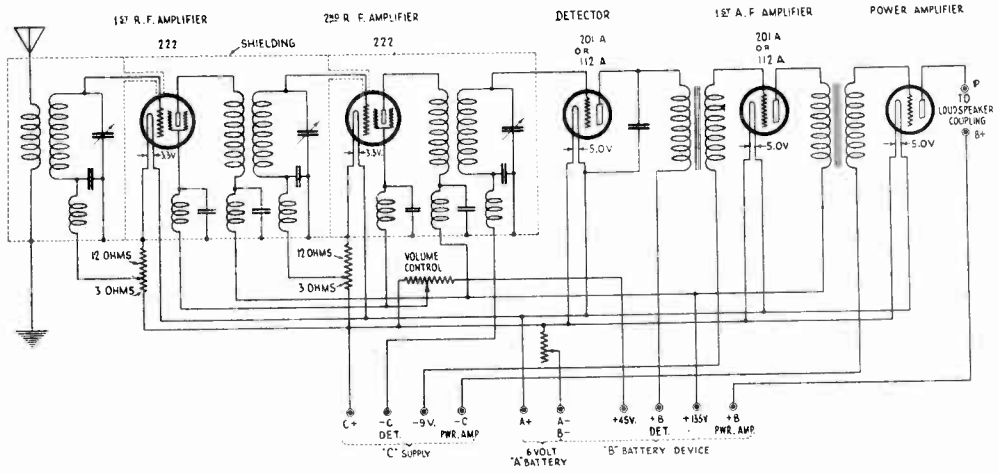

Figure 12

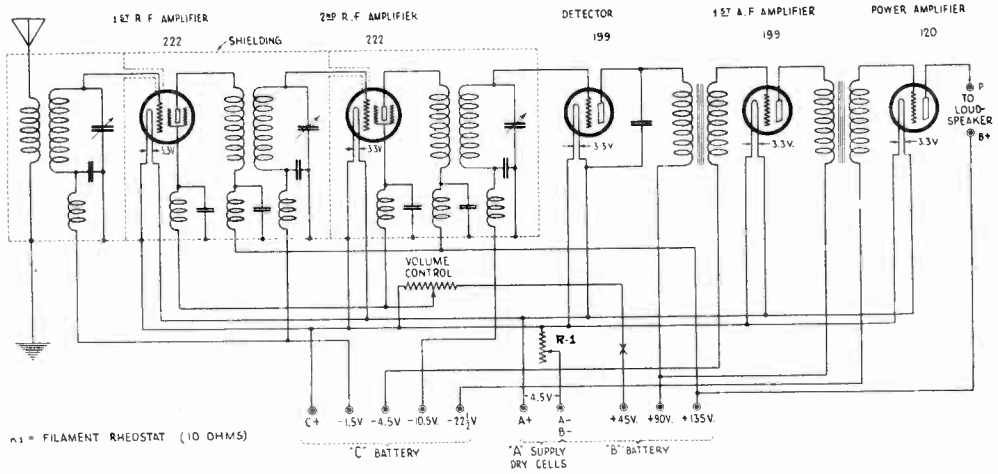

Figure 13

When the 222 type is used as a screen-grid radio-frequency amplifier, neutralization of the inter-electrode capacity between grid and plate to prevent feed-back through the tube is unnecessary because of the internal shielding by the screen. It is necessary, however, to take every precaution to avoid external coupling between the grid and plate circuit elements if stable operation of the 222 is to be obtained in circuits designed to give maximum gain per stage.

In multi-stage amplifier circuits, it is necessary to completely and effectively shield each stage, and to include within the stage

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shield all of the component parts of that stage. You can understand this arrangement by referring to Figures 12 and 13. Unless the coils and condensers of the various stages are shielded from each other, the amplification possibilities of the 222 cannot be fully realized.

If only a single 222 radio-frequency stage is used, it may not be necessary to shield this stage completely for reception of broadcast frequencies. Sufficient shielding will usually be obtained by placing the grid coil and condenser within a grounded metallic shield. In some cases it may be necessary to shield the 222 by a metallic jacket fitting closely over the tube and having an insulated opening at the top for the grid cap. The jacket should extend down at least to the base of the 222 and should be connected to either one of the filament terminals of the socket. The control grid lead should be kept as short as possible and should be spaced from other circuit elements.

The grid and plate circuit returns should be made to the negative filament terminal. The grid bias voltage of - 1.5 volts may be obtained from a "C" battery or from the drop in the 12 ohm portion of the tapped 15 ohm resistor which was previously mentioned. It should be noted that the tapped resistor method of obtaining the control-grid bias is usable only when the filament of the 222 is operated from a 6 volt "A" supply.

As a means of reducing coupling in the circuits external to the tube, the use of radio-frequency filters in all of the leads entering the stage shields as shown in Figures 12 and 13, is recommended. When filters are used the impedance of the circuit from screen to ground is kept as low as possible by the use of by-pass condensers.

In general, properly designed radio-frequency transformers are preferable to impedances for inter-stage coupling, and especially so in cases where a high impedance "B" supply device may cause oscillation below radio frequencies. If, however, impedance coupling is used between stages it is best to employ a blocking condenser having a capacitance of 0.00025 mfd. and a grid lead of from 2 to 5 megohms.

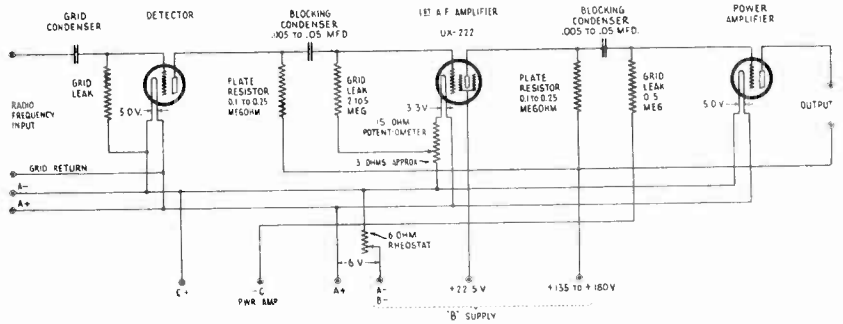


Figure 14

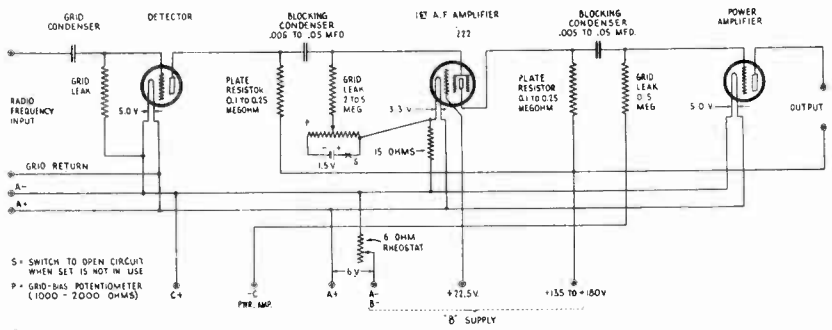


Figure 15

If the 222 type is to be operated as a screen-grid audio-frequency amplifier or as a space charge grid audio-frequency amplifier, resistance coupling should be used in its plate circuit. For either case, the value of the plate coupling resistor should be of the order of from 100,000 to 250,000 ohms. With the value of 250,000 ohms, a voltage amplification of 40 per stage should be obtained from either type of circuit. Suitable values of grid leaks and blocking condensers are shown in Figures 14 and 15. In Figure 14 you see a typical screen grid audio-amplifier circuit while Figure 15 gives a typical space charge grid audio-amplifier circuit.

SCREEN GRID R-F AMPLIFIER - TYPE 222

Rating and Data

Filament Voltage	3.3	volts
Filament Current	.132	ampere
Plate Voltage, Maximum and Recommended	135	volts
Grid Voltage (C-Bias)	-1.5	volts
Screen Voltage, Recommended	+45	volts
Plate Current	1.5	milliamperes
Screen Current	not over 1/3	of plate current
Plate Resistance	850,000	ohms
Amplification Factor	300	
Mutual Conductance	350	micromhos
Direct Inter-Electrode Capacitances		
Effective Grid-Plate	0.0025	mmf. maximum
Input	3.5	mmf. approx.
Output	12	mmf. approx.

In the following paragraphs we discuss about the special considerations concerning operating voltages and characteristics. When the 222 type is employed as a screen-grid radio-frequency amplifier, critical adjustment of the plate or screen voltage is not required. A plate voltage as low as 90 volts may be used but in special cases a screen voltage not exceeding 67.5 volts may be found desirable.

If the 222 is operated as a screen-grid audio-frequency amplifier, a plate supply voltage of from 135 to 180 volts applied through a plate coupling resistor of from 100,000 to 250,000 ohms is recommended. Under these conditions, the screen is operated preferably with + 22.5 volts, and the grid with from – .75 to – 1.5 volts. A

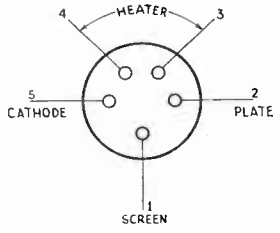
higher value of screen voltage may be used but because of the greater voltage amplification obtained at the increased voltage, more critical circuit adjustment will be required.

When the 222 is connected as a space charge grid audio-frequency amplifier, the inner or control grid is operated at -22.5 volts to neutralize the electron space charge around the filament. The outer grid then becomes the control-grid and should be biased negatively by from 0 to - 1.5 volts depending upon the conditions of operation. For best results, the use of a variable control-grid bias potentiometer as shown in Figure 15, is recommended.

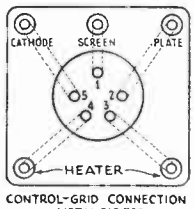
The screen-grid audio-frequency connection, in comparison with the space charge grid connection, will give somewhat lower maximum amplification but it will permit of better audio-frequency fidelity.

SCREEN GRID R-F AMPLIFIER.....A-C HEATER - TYPE 224

The 224 vacuum tube is a screen-grid amplifier containing a heater element which permits operation from alternating current. It is recommended for use primarily as a radio-frequency amplifier in carefully shielded circuits especially designed for it but it may also be effectively used as a space charge grid tube or as a double grid tube in special circuits as in the case of the 222 type which we just discussed.



LOOKING AT BOTTOM OF BASE



CONTROL-GRID CONNECTION METAL CAP TOP
SOCKET CONNECTION

Figure 16

The five-prong base of the 224 type requires the standard UY socket. As with all types of tubes the socket should make firm, large surface contact on the prongs to minimize contact resistance. In Figure 16 we have drawn a sketch showing the socket connections for this tube and keep in mind that the connection for the control grid is made to the metal cap at the top of the tube.

THE HEATER CONNECTION. The heaters of the 224 tube should be connected in parallel, as shown in Figure 17. The transformer winding supplying the heaters should be designed to maintain 2.5 volts across the heaters of the total number of 224 tubes used in the receiver. Due to the high current and low voltage all connections in the heater circuit must be particularly low resistance and all heater circuit

leads hould be of high current carrying capacity with all splices well soldered. The heater leads to the different tubes should be as nearly of equal length as is found practicable to make them and all leads carrying alternating current should be of twisted pair.

THE CATHODE CONNECTION. Connection of the cathode to the heater should be made (1) preferably to the movable arm of a potentiometer connected across the heater winding of the power transformer, or (2) to a mid-tapped resistor across the heater winding, or (3) to the mid-point of the heater winding itself. In some circuits, biasing of the heater negative with respect to the cathode by not more than 9 volts may be helpful in reducing hum.

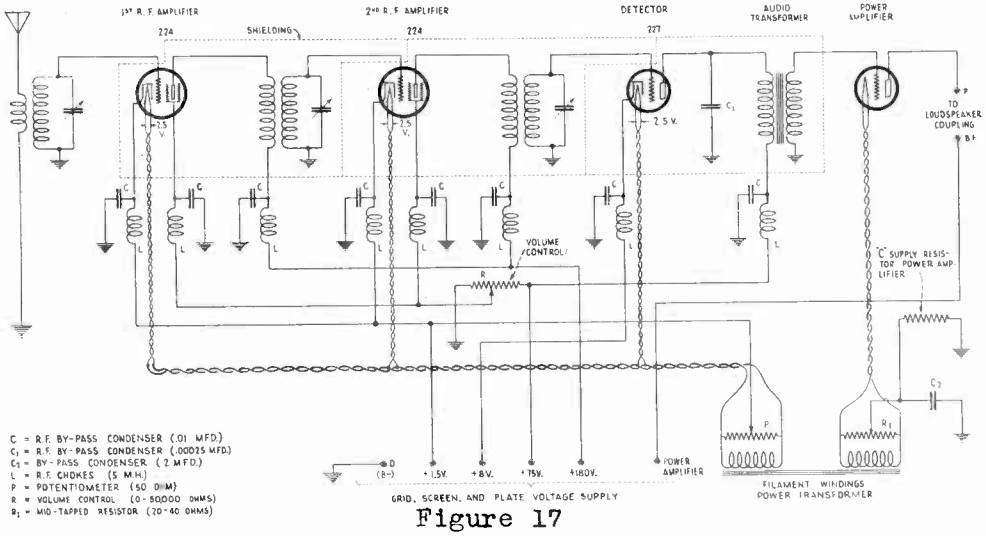


Figure 17

VOLTAGE FOR THE SCREEN GRID. The diagram in Figure 17 illustrates a typical a-c screen grid radio-frequency amplifier circuit. It shows how the screen voltage obtained from the definite voltage tap source may be made variable between 0 and 75 volts by the use of a potentiometer, R, marked "VOLUME CONTROL." Since the voltage applied to the screen is reduced by adjustment of the potentiometer, R, the mutual conductance therefore, of the 224 is decreased with consequent reduction in volume and this action makes a potentiometer a satisfactory volume control for the receiver.

A-C LINE VOLTAGE. The source of power for operating the heaters of the 224 tubes may be one of the secondary windings on the power transformer incorporated in the radio set, or it may be the secondary of a separate transformer. In either case, to obtain from the secondary a heater voltage of 2.5 volts, the transformer primary must be supplied with its rated voltage.

CIRCUIT REQUIREMENTS. When the 224 type is used as a screen-grid amplifier, neutralization of the inter-electrode capacity between grid and plate to prevent feed-back through the tube is unnecessary because of the internal shielding by the screen. It is necessary, however, to take every precaution to avoid external coupling between the grid and plate circuit elements if stable operation of the 224 is to be obtained in circuits designed to give maximum gain per stage.

SCREEN GRID R-F AMPLIFIER.....A-C HEATER - TYPE 224

Rating and Data

Heater Voltage	2.5	volts a-c or d-c
Heater Current	1.75	amperes
Plate Voltage, Maximum and Recommended	180	volts
Grid Voltage (C-Bias)	-1.5	volts
Screen Voltage, Maximum	+75	volts
Plate Current	4	milliamperes
Screen Current	not over 1/3	of plate current
Plate Resistance	400,000	ohms
Amplification Factor	420	
Mutual Conductance	1050	micromhos

Direct Inter-Electrode Capacitances
Grid-Plate 0.01 mmf. maximum; Input 5 mmf. approx.; Output 10 mmf. approx.

In multi-stage amplifier circuits, it is necessary to completely and effectively shield each stage, and to include within the stage shield all of the component parts of that stage, as you will understand by referring to Figure 17. Unless the coils and condensers of the various stages are shielded from each other, the amplification possibilities of any screen grid tube cannot be realized.

If the 224 type is to be used as a screen-grid detector for either grid leak detection or grid bias detection, the latter being called power detection, resistance coupling should be used in its plate circuit. A value of from 200,000 to 500,000 ohms is best suited for the plate coupling resistor. All of the voltages, except the 1.5 volts for the heater, may be supplied from taps on the same "B" supply device. Neither the plate nor the screen voltage is critical.

The volume of the receiver may be effectively controlled by means of a potentiometer connected as shown in Figure 17, this arrangement being similar to the connections shown in Figures 12 and 13 or by a variable grid resistor inserted in the cathode circuit through which the plate current must flow.

SCREEN GRID POWER DETECTOR. If the 224 type is used as a screen-grid detector, the grid bias method of detection is recommended because of its ability to handle large input voltages without overloading. For this method the following suitable operating values are suggested: a plate supply voltage of 200 volts applied through a plate coupling resistor of 250,000 ohms, a positive screen voltage of 45 volts, and a negative grid bias (approximately 5 volts) so adjusted that a plate current of 0.1 milliampere is obtained with no a-c input signal. Fig. 18 shows the principle of connecting a screen-grid power detector.

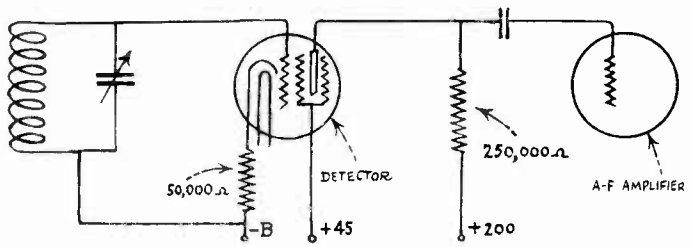


Figure 18

TYPES WD 11 AND WD 12 FOR USE WITH DRY CELLS.

These tubes are among the earliest types of dry cell tube and were designed to be used with one or more #6 dry cells in parallel for filament supply. The -11 type tube has a special arrangement of prongs and so requires a special socket whereas the -12 type was designed to be used in a regular UX type socket. The electrical characteristics of both tubes are the same, hence, in either case the oxide coated filament consumes a quarter of an ampere at 1.1 volts and the plate may be operated with from 40 to 90 volts. Each type is a general purpose tube and can be used either as an r-f or a-f amplifier, or detector.

TYPES WD-11 AND WD-12

Rating and Data

Filament Voltage			1.1	volts
Filament Current			0.25	ampere
Plate Voltage	90	67	45	volts
Grid Voltage (C-Bias)	-4.5	-3	-.5 to 1.5	volts
Amplification Factor			6.6	

For use as a detector the grid return should be connected to the positive side of the filament and for this specific use a 2 megohm grid leak and .00025 mfd. condenser are recommended with 22½ to 45 volts on the plate.

TYPE 199 GENERAL PURPOSE BATTERY-TYPE TUBE.

These tubes are also general purpose battery-type tubes being designed to give more economical battery consumption than the -11 or -12 type. They may be used either as amplifiers or detectors, when used as a detector the grid circuit return should be connected to positive filament and a 3 megohm grid leak and .00025 grid condenser are recommended. Due to the low interelectrode capacity these tubes make good r-f amplifiers and, also, they can be used in the a-f stages to operate small speakers. Care should be taken to use the proper negative bias on the grid of the 199 whenever it is used as an amplifier.

TYPE 199 TUBE

Rating and Data

Filament Voltage	3.3	volts
Filament Current	.063	ampere
Amplification Factor	6.6	
Plate Voltage	90	volts
Grid Voltage (C-Bias)	-4.5	volts

The filament is of the thoriated tungsten type which may be reactivated if desired. Since the normal consumption is .06 ampere at 3.3 volts only three dry cells are necessary to supply the filament current.

TYPE 120 AUDIO OUTPUT AMPLIFIER.

This tube is a power amplifier designed to be used in the last stage of a receiver employing 199 type tubes. It operates with the same filament voltage as the 199 but takes twice as much current to heat the filament.

TYPE 120 AUDIO OUTPUT AMPLIFIER

Rating and Data

Filament Voltage	3.3	volts
Filament Current	0.132	ampere
Amplification Factor	3.3	
Plate Voltage (max.)	135	volts
Grid Voltage (C-Bias)	-22.5	volts

As the characteristic charts indicate, the 120 requires higher plate voltage and greater bias than the 199 and gives more power output without distortion.

TYPE 201-A STORAGE BATTERY TUBE.

For many years the 201-A tube has been the standard general purpose battery type tube. It was at one time the most popular type tube used in radio receivers where the space occupied by the batteries was not of great importance. Although the battery consumption is quite low for a 201-A filament yet a storage battery is recommended instead of dry cells. The plate current is greater than for the 199 and, therefore, higher capacity "B" batteries are recommended.

The filament is of the thoriated tungsten type rated at 5 volts and 0.25 ampere. The UV-type base with short prongs was first used with this tube but now the base has been changed to fit a standard UX socket.

TYPE 201-A TUBE

Rating and Data

Filament Voltage			5	volts
Filament Current			0.25	ampere
Amplification Factor			8	
Plate Voltage	(max.) 135	(recommended)	90	volts
Grid Voltage (C-Bias	-9		-4.5	volts

Detector operation is not critical and, as in the case of other types of tubes just discussed, a 2 megohm grid leak and 0.00025 mfd. condenser are recommended. The tube also makes a good r-f and a-f amplifier and, as mentioned before for other tubes, care should be taken to use the proper C-bias.

TYPE 240 USED WITH RESISTANCE COUPLING.

This tube is designed primarily to be used as a detector or audio-frequency amplifier where resistance coupling is desired. It is similar in appearance to the 201-A but the grid and plate construction differs to secure higher amplification and the plate impedance is also much higher than that of the 201-A.

TYPE 240 TUBE

Rating and Data

Filament Voltage	5 volts
Filament Current	.25 ampere
Amplification Factor	30

240 USED AS AMPLIFIER

Plate Voltage	135 volts (recommended)		180	volts (max.)
Grid Voltage (C-Bias)	-1.5 volts		-3.0	volts
Plate Coupling Resistance	250,000 ohms		250,000	ohms

240 USED AS DETECTOR

(Grid Leak Detection)

Plate Voltage	135 to 180	volts
Plate Coupling Resistance	250,000	ohms
Grid Leak	2 - 5	megohms

(Grid Bias Detection)

Plate Voltage	135 volts	180	volts
Plate Coupling Resistance	250,000 ohms	250,000	ohms
Grid Voltage (C-Bias)	-3 volts	-4.5	volts

The above chart gives the various ratings for the 240 when used either as an amplifier, or a grid-leak or grid-bias detector. As just stated, this tube may be used for either grid leak or grid bias detection, the first giving higher sensitivity and the latter freedom from distortion on high signal input voltages. When used in a resistance coupled audio amplifier the 240 gives quite uniform amplification from 30 to 10,000 cycles.

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TYPE 112-A AMPLIFIER.

This is an oxide coated storage battery tube, having a lower plate resistance than the 201-A. It may be used as a detector, r-f amplifier or a-f amplifier. For detector use it is recommended to use 45 volts on the plate, a 0.00025 mfd. grid condenser and a 2 to 3 megohm leak. Due to the difference in interelectrode capacity and plate resistance it may be difficult to control if used in a radio-frequency circuit but the low impedance, however, makes this tube most suitable for use in transformer coupled audio amplifiers. It also makes a good power amplifier having a greater output than the 201-A but less than the 171-A.

TYPE 112-A AMPLIFIER

Rating and Data

Filament Voltage			5	volts
Filament Current			.25	ampere
Amplification Factor			8.5	
Plate Voltage	135	volts (recommended)	180	volts(max.)
Grid Voltage	-9	volts	-13.5	volts

TYPE 250 POWER AMPLIFIER TUBE.

This tube is a heavy duty power amplifier intended for use in installations where more undistorted power output is required than for average home use. The 250 is larger in size than the 210 and requires greater bias for the same plate voltage. For this reason it cannot be used in a set formerly using a 210 unless the set is changed to increase the bias. When this is done it will give a greater power output than the 210. This tube has an oxide coated filament rated at 7.5 volts, 1.25 amperes and draws higher plate current and has lower impedance than the 210.

TYPE 250 AMPLIFIER

Rating and Data

Filament Voltage				7.5	volts
Filament Current				1.25	amperes
Amplification Factor				3.8	
Plate Voltage	250	350	400	450	volts
Grid Voltage (C-Bias)	-45	-63	-70	-84	volts
Power Output (milliwatts)	1000	2400	3400	4600	milliwatts

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TYPES 236, 237 and 238 DESIGNED FOR AUTOMOBILE RADIO RECEIVERS

This group of three tubes consists of a screen-grid tube, a general purpose tube and a power output pentode. All three are of the high vacuum type and employ coated cathodes indirectly heated. The cathodes, which are the same for all three types, have been carefully designed to insure uniform heating over as wide a range of heater voltages as possible in order that the tubes will perform satisfactorily under the normal voltage variation of automobile batteries during charge and discharge. This feature together with that of the general freedom from microphonic and battery circuit disturbances of the heater-cathode type, make these new tubes particularly suited for use in automobile receivers.

The 236 Screen-Grid tube is particularly recommended for operation as a radio-frequency amplifier in circuits especially designed for it. It may be employed also as a screen-grid detector.

The 237 general purpose tube is useful either as detector, amplifier or oscillator.

The 238 power amplifier pentode has been designed to give good output volume consistent with the relatively low voltage and limited capacity of the plate supply battery.

The 236 and 237 will also be found especially adaptable to the design of radio receivers for operation from the d-c power line. In such service the heaters of these two types may be connected in series to operate at 0.3 ampere. This is made possible by the uniform heating of the cathode over a wide voltage range to offset normal line voltage variation.

TYPE 236 FOR AUTOMOBILE SETS

This screen-grid tube may be used as either a radio-frequency amplifier, a detector or an intermediate-frequency amplifier in circuits especially designed for it. The 236 employs a coated cathode of the semi-quick-heater type designed for d-c operation only. Owing to the special cathode design, the heater voltage may range between 5.5 and 8.5 volts during the charge and discharge cycles of the battery without appreciably affecting the performance or serviceability of this tube. No resistor in the heater circuit is required for this type operated from a 6-volt battery.

The socket required by the 236 is of the standard UY type and may be mounted to hold the tube in either a vertical or horizontal position. Socket connections are the same as for a UY-224.

Stable operation of the 236 in radio-frequency circuits designed to give maximum gain per stage requires separation of the input and output circuit elements. In general, with multi-stage amplifier circuits, it is necessary to use complete stage shielding enclosing all the components of each stage. Unless this is done, the amplification possibilities of the 236 will not be realized. The use of radio-frequency filters in all leads entering the stage shields is advised to reduce

coupling in external parts of the circuit. In regard to heater to cathode bias it should not exceed 45 volts.

Since the screen current of individual tubes is subject to variation, the use of a resistance in series with the plate voltage source for the screen voltage supply will result in poor regulation and uncertain operating screen voltages. It is recommended therefore, that the screen voltage be obtained from either a tap on the plate battery, or from a potentiometer or bleeder circuit which maintains the screen voltage approximately constant at the recommended value. If a bleeder circuit or potentiometer is used, its electrical design should be such as to provide adequate screen voltage regulation; otherwise, the effect will be essentially the same as that of a series resistor with resultant poor regulation. The volume of the receiver should be controlled preferably by varying the grid voltage. The control adjustment should be such as to impress not less than - 1.5 volts on the grid when recommended voltages are applied to the screen. The use of some device for reducing the signal input to the first radio-frequency tube will be necessary where strong local signals will cause high values of peak grid voltage.

TYPE 236 FOR AUTOMOBILE SETS

Rating and Data

Heater Voltage			6.3	volts d-c
Heater Current			0.3	ampere
Plate Voltage	90**	135	135*	volts
Screen Voltage	55**	67.5	75*	volts
Grid Voltage	-1.5**	-1.5	-1.5*	volts
Plate Current	1.8	3	3.5	milliamperes
Screen Current		not over 1/3	of plate current	
Plate Resistance	200,000	300,000	250,000	ohms
Amplification Factor	170	315	275	
Mutual Conductance	850	1050	1100	micromhos

The 236 may be employed as a screen-grid detector of either the grid-bias or grid-leak type. For both of these connections resistance coupling may be used with a plate coupling resistor. An equivalent reactor may be substituted for the plate resistor where greater output from low percentage modulated signals is desired. For most sensitive detection with resistance coupling, it will be necessary to reduce the screen voltage to from 20 to 45 volts. For plate detection the bias may be secured either from a fixed voltage source or by automatic biasing from a resistor in the cathode circuit.

TYPE 237 FOR AUTOMOBILE SETS

This three-electrode tube may be used in circuits of conventional design as either an amplifier, a detector or an oscillator. The tube employs a coated cathode of the semi-quick-heater type designed for d-c operation only. Owing to the special cathode design, the heater voltage may range between 5.5 and 8.5 volts during the charge and discharge cycles of the battery without appreciably affecting the performance of serviceability of this tube.

TYPE 237 FOR AUTOMOBILE SETS

Rating and Data

Heater Voltage		6.3	volts d-c
Heater Current		0.3	ampere
Plate Voltage	90**	135*	volts
Grid Voltage	-6**	-9	volts
Plate Current	2.7	4.5	milliamperes
Plate Resistance	11,500	10,000	ohms
Amplification Factor	9	9	
Mutual Conductance	780	900	micromhos
Load Resistance***	14,000	12,500	ohms
Undistorted Power Output	30	75	milliwatts
Approximate Inter-Electrode Capacitances			
Grid to Plate	2.0 mmf.		
Grid to Cathode	3.3 mmf.		
Plate to Cathode	2.3 mmf.		
Base		small UY	
Socket		UY	

***Optimum load resistance for maximum undistorted power output as given.
*Recommended values for use in automobile receivers.
**Recommended values for use in receivers designed for 110 volt d-c operation.

In detector service, the 237 may be used either with grid lead and grid condenser or with grid bias. If grid leak detection is used, a condenser of 0.00025 mfd. and a grid leak of from 1 to 5 megohms will give excellent sensitivity. However, more stable operation and better quality will be obtained by using a low value of grid leak. For plate detection the bias may be secured either from a fixed voltage source or by automatic biasing from a resistor in the cathode circuit. The heater to cathode bias should not exceed 45 volts as in the case of type 236, and the socket connections are the same as for a UY-227.

TYPE 238 - POWER PENTODE FOR AUTOMOBILE SETS

The 238 is a screen-grid tube designed primarily for giving large audio power output for relatively small signal voltages impressed on the grid. This is made possible by the addition of a "suppressor" grid between the screen and the plate. The suppressor is connected inside the tube to the cathode and is therefore operated at the same potential as the cathode. When connected and operated in this manner, the suppressor is effective in practically eliminating the secondary emission effects which limit the power output from four-electrode screen-grid types.

Other considerations already mentioned in regard to the special types of automobile tubes are that the heater to cathode bias should not exceed 45 volts and the grid bias for the 238 may be obtained either from a fixed voltage source or by automatic self-biasing from a resistor in the cathode circuit. Also, this tube employs a coated cathode of the semi-quick-heater type designed for d-c operation only

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and owing to the special cathode design, the heater voltage may range between 5.5 and 8.5 volts during the charge and discharge cycles or the battery without appreciably affecting the performance or serviceability of this tube.

TYPE 238 - POWER PENTODE FOR AUTOMOBILE SETS

Rating and Data

Heater Voltage	6.3	volts
Heater Current	0.3	ampere
Plate Voltage, Recommended	135	volts
Screen Voltage, Recommended	135	volts
Grid Voltage	-13.5	volts
Plate Current	8	milliamperes
Screen Current	2.5	milliamperes
Plate Resistance	110,000	ohms
Amplification Factor	100	
Mutual Conductance	900	micromhos
Load Resistance	15,000	ohms
Undistorted Power Output	375	milliwatts
Base	small	UY
Socket		UY

THE 2-VOLT TYPE TUBES FOR BATTERY OPERATION

2-VOLT TUBE - DETECTOR AND AMPLIFIER - TYPE 230

The 230 is a new general purpose tube of the three electrode, high vacuum type. It employs a strong metallic filament coated with alkaline earth compounds. The filament has been designed to take as little power as possible consistent with satisfactory operating performance. This new tube, therefore, is particularly suited for use either as a detector or amplifier in radio receivers operating from dry-cells or from a storage battery where economy of filament current drain is important.

This 2 volt tube should be mounted in a vertical position and its socket and connections are the same as for the 199 tube. It should be mentioned that although the 230 is very free from microphonic disturbances, cushioning of its socket may be desirable.

The coated filament of the 230 should be operated at its rated value of 2.0 volts. This voltage may be supplied from dry-cells or from a single cell storage battery, but in either case an adjustable filament rheostat must be used together with a permanently installed indicating instrument to secure the proper filament voltage. This instrument should be either a voltmeter to indicate the terminal e.m.f. or a milliammeter to indicate the current drain. This requirement is applicable to all of the three types of 2 volt tubes, namely, the 230, 231 and 232 tubes. Bear in mind that fixed filament resistors will not give sufficient regulation to permit of satisfactory performance.

When this tube is used as a detector with a grid condenser and leak, the 230 tube should preferably be operated with a plate voltage of

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not more than 45 volts. The grid condenser and leak may be of usual sizes. However, as an amplifier, the 230 should always be used with a negative grid bias and for a plate voltage of 90 volts, it is best to use a grid bias of 4.5 volts.

2-VOLT TUBE - DETECTOR AND AMPLIFIER - TYPE 230

Rating and Data

Filament Voltage	2.0	volts
Filament Current	0.06	amperes
Plate Voltage (Maximum)	90	volts
Grid Voltage (C-Bias)	-4.5	volts
Plate Current	2.0	milliamperes
Plate Resistance	12,500	ohms
Amplification Factor	8.8	
Mutual Conductance	700	micromhos

Further, let us advise you that the 230 tube cannot be substituted for the 199 tube in radio sets designed for the latter, without circuit modifications. Suitable precautions must be taken to limit the filament voltage to 2.0 volts. In addition, the filament circuit must be altered to conform to the requirements of this new tube. If these tubes are used in tuned radio-frequency receivers not especially designed for them it may be necessary to readjust the neutralizing condensers or grid resistors before stable operation is obtained.

2-VOLT TUBE - POWER AMPLIFIER - TYPE 231

The 231 type tube is a new power amplifier tube of the three electrode, high vacuum type. It employs a strong metallic filament of the coated type which has been designed to take as little power as possible consistent with satisfactory operating performance. This new 231 tube, therefore, is particularly suited for use as the power output tube in radio receivers which operate with 230 or 232 type tubes. Both of the latter type may be used in the same receiver in conjunction with the 231, hence, all three types of the new 2 volt tubes may be employed in a single receiver.

2-VOLT TUBE - POWER AMPLIFIER - TYPE 231

Rating and Data

Filament Voltage	2.0	volts
Filament Current	0.130	ampere
Plate Voltage, Maximum and Recommended	135	volts
Grid Voltage (C-Bias)	-22.5	volts
Plate Current	8	milliamperes
Plate Resistance	4,000	ohms
Amplification Factor	3.5	
Mutual Conductance	875	micromhos
Undistorted Power Output	170	milliwatts

The 231 should be mounted in a vertical position and is to be used with a socket having connections the same as for the 199 or 120. It has been found that provision for cushioned sockets to prevent microphonic disturbances will not usually be necessary when this tube feeds directly into the loudspeaker.

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The recommended and maximum plate voltage for the 231 tube is 135 volts while the corresponding grid bias is - 22.5 volts. Under these operating conditions the plate current, which is 8 ma., is not high enough to require the use of a loudspeaker coupling device.

The 231 tube cannot be substituted for the 120 tube unless the filament circuit is altered to conform to the requirements of this new power output tube since the filament voltage must be limited to 2.0 volts.

2-VOLT TUBE - SCREEN GRID R-F AMPLIFIER - TYPE 232

The 232 type tube is a new screen grid tube recommended for use primarily as a radio-frequency amplifier. It employs a strong metallic filament of the coated type, which has been designed to take as little power as possible consistent with satisfactory operating performance. This new tube, therefore, is particularly useful in the radio-frequency stages of specially designed radio receivers operating from dry cells or from a storage battery where economy of filament current drain is important. The control grid is electrostatically shielded from the plate by means of an extra grid placed between plate and control grid and operated at a suitable positive potential. The resultant reduction in plate to control-grid capacity makes high voltage amplification per stage practical without external capacity neutralization circuits. This isolation of plate and grid results in a small change of plate current with a change of plate potential. The plate resistance, therefore, is high and averages about 800,000 ohms.

2-VOLT TUBE - SCREEN GRID R-F AMPLIFIER - TYPE 232

Rating and Data

Filament Voltage	2.0	volts
Filament Current	0.06	ampere
Plate Voltage, Maximum and Recommended	135	volts
Grid Voltage (C-Bias)	-3	volts
Screen Voltage, Maximum	67.5	volts
Plate Current	1.5	milliamperes
Screen Current	not over 1/3	of plate current
Plate Resistance	800,000	ohms
Amplification Factor	440	
Mutual Conductance	550	micromhos
Effective Grid-Plate Capacitances	0.02	mmf. maximum

The 232 tube should be mounted in a vertical position. The socket connections for the 232 are the same as for the 222 type tube. Although the 232 is very free from microphonic disturbances, cushioning of its socket may be desirable.

The connection for the control grid is made to the metal cap at the top of the glass envelope as is the usual procedure after placing screen-grid type tubes in their sockets.

The positive voltage for the screen should be obtained from a tap on the plate battery and, therefore, never attempt to obtain the screen voltage by connecting the screen through a series resistor to a high

plate voltage source. Such a series resistor connection will not in general be satisfactory for screen voltage supply because of the uncertain drop produced by the considerable differences in screen currents of individual tubes.

Stable operation of the 232 tube in circuits designed to give maximum gain per stage requires separation of the input and output circuit elements. In general, it is necessary to use complete stage shielding including all the components of each stage. The use of filters in all leads entering the stage shields is advisable to reduce coupling in external parts of the circuit.

It is recommended that the operating voltage be applied to the 232 tube as follows: maximum plate voltage to be 135 volts with all corresponding negative grid bias of 3 volts, and a maximum positive screen voltage of 67.5 volts. You will find when using tubes of this type that neither plate nor screen voltage is critical. The control-grid bias for this tube when working on B-battery operated receivers should be obtained from a C-battery. The 232 tube cannot be substituted for the 222 tube in circuits designed for the latter, without circuit modifications, that is, the filament and grid circuits must be altered to conform to the requirements of this new screen-grid tube.

VARIABLE MU TUBE - TYPE 235

This most recent screen-grid tube has been developed primarily for use in radio-frequency and intermediate-frequency amplifier stages. It is effective in reducing cross-modulation, and modulation distortion over the entire range of received signals. Furthermore, its design is such as to permit easy control of a large range of signal voltages without the use of local-distant switches or antenna potentiometers. This feature makes the tube adaptable to automatic volume control design.

VARIABLE MU TUBE - TYPE 235

Tentative Rating and Normal Characteristics

Filament Voltage	2.5	volts
Filament Current	1.75	amperes
Plate Voltage, Recommended	180	volts
Screen Voltage, Recommended	75	volts
Grid Voltage	— 1.5	volts
Plate Current	9	milliamperes
Screen Current	not over 1/3	of plate current
Plate Resistance	200,000	ohms (approx.)
Mutual Conductance	1,100	micromhos
Approximate Inter-Electrode Capacitances		
Grid to Plate	.010	mmf. maximum
Input	5	mmf.
Output	10	mmf.
Base and Socket		UY

The 235 employs a cathode of the quick-heater type. Its heater should be operated at its normal rated voltage of 2.5 volts at the normal design line voltage. It is interesting to note that a recent survey of

normal socket voltage conditions over the United States has established that 113 volts represents average operating conditions.

This tube has a very long characteristic curve that gradually drops off which indicates that very strong grid biases can be applied to the grid before the plate current reaches zero. In effect the signal voltage resulting from the oscillating current in the antenna system picks out the part of the characteristic curve of the tube it chooses to work upon, this being determined by the carrier voltage of this signal. A strong local signal may place a bias on the grid as low as 30 or more volts, whereas the desired signal which is much weaker in intensity may be working around a point which may be only a few volts or even tenths of volts negative. This tube's long characteristic curve is due to the special design of the tube elements which are made in different forms. For instance, the grid may be tilted, or the spacing between the wires may be greater at one part of the grid structure than at another, or the diameter may be non-uniform, that is, wide at one place and narrow at another and so on. Observe that curves A and B in Figure 19 illustrate the idea of how a variable mu tube combines the features of both a low-mu and high-mu tube which permits this tube to work over a wide range of input signal voltages. Curve A is the characteristic for a low-mu tube and curve B is the characteristic for a high-mu tube while the long curve drawn in solid line illustrates the combined characteristics. The various arrangements of tube structure cause a different, or variable mu-factor in operation for electrons emitted from the various elements of the cathode. When the grid bias is low, or near zero, the electron flow is such that current flows from all of these elements but as the grid bias becomes more negative the current from the elements having the higher mu-factors is cut off gradually at a certain rate.

The cathode should be connected directly to the center-point of the heater circuit. If this arrangement is not practical in some receiver designs, the heater may be made negative with respect to the cathode by a potential difference not exceeding 45 volts.

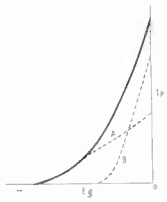

Figure 19

Since the screen current of individual tubes is subject to considerable variation, the use of resistance in series with a high voltage source for the screen voltage supply will result in poor regulation and uncertain operating screen voltages. It is recommended, therefore, that the screen voltage be obtained from a potentiometer or from a bleeder circuit which maintains the screen voltage approximately constant at 75 volts. The electrical design of the potentiometer or bleeder should be such as to draw several times the maximum screen current; otherwise, the effect will be essentially the same as that of a series resistor with resultant poor regulation. Radio-frequency choke filters for screen voltage supply are preferred, due to their low d-c resistance which insures satisfactory screen voltage regulation.

Since the variation in plate current over the operating range of this tube is about 9 milliamperes, the maximum current drain of several tubes may cause a large shift in power pack output voltage. It is, therefore, recommended that the screen voltage be adjusted to average 75 volts between the two extremes of the volume control setting.

Variation of the negative voltage applied to the grid will be found effective in changing the volume of the receiver. In order to utilize the full volume control range of this tube, an available grid bias voltage of approximately 75 volts will be required. This voltage should preferably be obtained from a potentiometer or bleeder circuit. If, however, the receiver is designed so that the required volume control can be obtained without exceeding 45 volts, the cathode resistor method of obtaining the grid bias control voltage is permissible.

The illustration below in Figure 20 shows a diagrammatic circuit for Super-Control R-F Amplifier RCA-235 and Power Amplifier Pentode RCA-247.

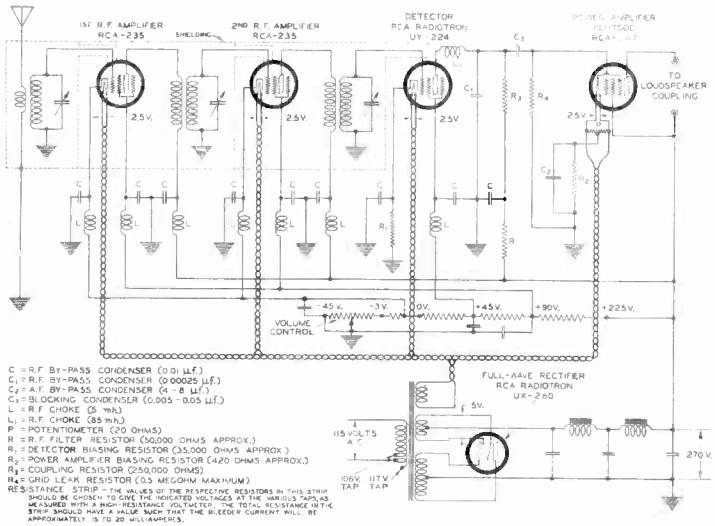

Figure 20

EXAMINATION QUESTIONS (V-13 #1.)

1. Explain the principle on which a pentode tube functions.
2. Calculate the "C" bias resistor for the 245 tube used in Figure 9 with 250 volts plate supply.
3. (a) Under what conditions would you use a 171-A tube with 90 volts applied to the plate and (b) with 180 volts applied?
4. How is screen grid voltage best obtained and how controlled?
5. What is the difference between space charge and screen grid connections?
6. Refer to Question 5. Which makes the better audio amplifier and why?
7. What advantage does the screen-grid type tube have over the 3-element tube as an r-f amplifier?
8. (a) Show by diagram how you would connect a loudspeaker to a 171-A tube, (b) to a 245 tube, and (c) Explain why for each case.
9. A 224 tube used as a detector has 200 volts applied to its plate thru a coupling resistor of 250,000 ohms. Assuming the plate current to be .1 milliampere what voltage is actually impressed on the tube?
10. Give the advantages of the type 235 tube over the type 224 tube.

AVERAGE CHARACTERISTICS CHART

DETECTORS AND AMPLIFIERS

Type	Use	Base	Max. Overall Dimensions Height	Max. Overall Dimensions Diam.	Filament Supply	Filament Terminal Volts	Filament Current Amperes	DETECTION Plate Supply Volts	DETECTION Plate Current Milliamp.	DETECTION Grid Return Lead To	AMPLIFICATION Plate Supply Volts	Grid Bias Voltage D. C. on Fil.	Grid Bias Voltage A. C. on Fil.	Plate Current Milli-amp.	Screen Grid Volts	A. C. Plate Resistance Ohms	Mutual Conductance Micromhos	Voltage Amplification Factor	Ohms Load for Maximum Undistorted Output	Maximum Undistorted Output Milliwatts
WD-11	Detector or Amplifier	WD-11	4 1/8"	1 3/16"	D. C.	1.1	0.25	45	1.5	+F	90	4.5	—	2.5	—	15500	425	6.6	15500	7
											135	10.5	—	3.0	—	15000	440	6.6	18000	35
WX-12	Detector or Amplifier	UX	4 11/16"	1 7/16"	D.C.	1.1	0.25	45	1.5	+F	50	4.5	—	2.5	—	15500	425	6.6	15500	7
											135	10.5	—	3.5	—	15000	440	6.6	18000	35
UX-112-A	Detector or Amplifier	UX	4 11/16"	1 13/16"	D. C.	5.0	0.25	45	4.0	+F	90	4.5	—	5.2	—	5600	1500	8.5	5600	30
											135	9.0	—	6.2	—	5300	1600	8.5	8700	120
UV-199	Detector or Amplifier	UV-199	3 1/2"	1 1/16"	D. C.	3.3	0.063	45	1.0	+F	90	4.5	—	2.5	—	15500	425	6.6	15500	7
UX-199	Detector or Amplifier	Small UX	4 1/8"	1 3/16"	D. C.	3.3	0.063	45	1.0	+F	90	4.5	—	2.5	—	15500	425	6.6	15500	7
UX-200-A	Detector	UX	4 11/16"	1 13/16"	D. C.	5.0	0.25	45	1.5	−F	Following UX-200-A Characteristics Apply Only for Detector Connection					30000	666	20	—	—
UX-201-A	Detector or Amplifier	UX	4 11/16"	1 13/16"	D. C.	5.0	0.25	45	1.5	+F	90	4.5	—	2.5	—	11000	725	8.0	11000	15
											135	9.0	—	3.0	—	10000	800	8.0	20000	55
UX-222	Radio Freq. Amplifier	UX	5 3/8"	1 13/16"	D. C.	3.3	0.132	—	—	—	135	1.5	—	1.5	45	850000	350	300	—	—
											135	1.5	—	3.3	67.5	600000	480	290	—	—
UX-222	Audio Freq. Amplifier	UX	5 3/8"	1 13/16"	D. C.	3.3	0.132	—	—	—	180†	1.5	—	0.3	22.5	2000000	175	350	—	—
UY-224	R. F. Amp. or Detector	UY	5 1/4"	1 13/16"	A. C. or D. C.	2.5	1.75	Refer to Technical Bulletin		Cath.	180	1.5	1.5	4.0	75	400000	1050	420	—	—
											180	3.0	3.0	4.0	90	400000	1000	400	—	—
UY-224	Audio Freq. Amplifier	UY	5 1/4"	1 13/16"	A. C. or D. C.	2.5	1.75	—	—	—	250‡	1.0	1.0	0.5	25	2000000	500	1000	—	—
UX-226	Amplifier	UX	4 11/16"	1 13/16"	A. C. or D. C.	1.5	1.05	—	—	—	90	5.0	6.0	3.8	—	8600	955	8.2	9800	30
											135	8.0	9.0	6.3	—	7200	1135	8.2	8800	80
											180	12.5	13.5	7.4	—	7000	1170	8.2	10500	180
UY-227	Detector or Amplifier	UY	4 11/16"	1 13/16"	A. C. or D. C.	2.5	1.75	45	3.5	Cath.	90	6.0	6.0	2.7	—	11000	820	9.0	14000	30
											135	9.0	9.0	4.5	—	9000	1000	9.0	13000	80
											180	13.5	13.5	5.0	—	9000	1000	9.0	18700	165
RCA-230	Detector or Amplifier	Small UX	4 1/4"	1 3/16"	D. C.	2.0	0.06	45	1.0	+F	90	4.5	—	2.0	—	12500	700	8.8	—	—
RCA-232	Radio Freq. Amplifier	UX	5 1/4"	1 13/16"	D. C.	2.0	0.06	—	—	—	135	3.0	—	1.5	67.5	800000	550	440	—	—
UX-240	Detector or Amplifier	UX	4 11/16"	1 13/16"	D. C.	5.0	0.25	135†	0.3	+F	135†	1.5	—	0.2	—	150000	200	30	—	—
								180†	0.4		180†	3.0	—	0.2	—	150000	200	30	—	—

*For Grid-Bias Detection, refer to Technical Bulletins. †Applied through plate coupling resistor of 250000 ohms. ‡Applied through plate coupling resistor of 200000 ohms.

POWER AMPLIFIERS

UX-112-A	Power Amplifier	UX	4 11/16"	1 13/16"	D. C. or A. C.	5.0	0.25	—	—	—	135	9.0	11.5	6.2	—	5300	1600	8.5	8700	120
											180	13.5	15.0	7.6	—	5000	1700	8.5	10800	260
UX-120	Power Amplifier	Small UX	4 1/8"	1 3/16"	D. C.	3.3	0.132	—	—	—	135	22.5	—	6.5	—	6300	525	3.3	6500	110
UX-171-A	Power Amplifier	UX	4 11/16"	1 13/16"	A. C. or D. C.	5.0	0.25	—	—	—	90	16.5	19.0	12.0	—	2250	1330	3.0	3200	125
											135	27.0	29.5	17.5	—	1960	1520	3.0	3500	370
											180	40.5	43.0	20.0	—	1850	1620	3.0	5350	700
UX-210	Power Amplifier	UX	5 5/8"	2 3/16"	A. C. or D. C.	7.5	1.25	—	—	—	250	18.0	22.0	10.0	—	6000	1330	8.0	13000	400
											350	27.0	31.0	16.0	—	5150	1550	8.0	11000	900
											425	35.0	39.0	18.0	—	5000	1600	8.0	10000	1600
RCA-231	Power Amplifier	Small UX	4 1/4"	1 3/16"	D. C.	2.0	0.130	—	—	—	135	22.5	—	8.0	—	4000	875	3.5	—	170
UX-245	Power Amplifier	UX	5 5/8"	2 3/16"	A. C. or D. C.	2.5	1.5	—	—	—	180	33.0	34.5	25.0	—	1900	1850	3.5	3500	780
											250	48.5	50.0	34.0	—	1750	2000	3.5	3900	1600
UX-250	Power Amplifier	UX	6 1/4"	2 11/16"	A. C. or D. C.	7.5	1.25	—	—	—	250	41.0	45.0	28.0	—	2100	1800	3.8	4300	1000
											350	59.0	63.0	45.0	—	1900	2000	3.8	4100	2100
											400	66.0	70.0	55.0	—	1800	2100	3.8	3670	3400
											450	80.0	84.0	55.0	—	1800	2100	3.8	4350	4600

RECTIFIERS

UX-280	Full-Wave Rectifier	UX	5 5/8"	2 3/16"	A. C.	5.0	2.0	1 { A. C. Voltage per Plate (Volts RMS) ... 350 D. C. Output Current (Maximum MA.) ... 125 2 { A. C. Voltage per Plate (Maximum Volts RMS.) ... 400 D. C. Output Current (Maximum MA.) ... 110	For D. C. Output Voltage delivered to filter of typical rectifier circuits, refer to Technical Bulletin.
UX-281	Half-Wave Rectifier	UX	6 1/4"	2 7/16"	A. C.	7.5	1.25	A. C. Plate Voltage (Maximum Volts RMS.) ... 700 D. C. Output Current (Maximum MA.) ... 85	For D. C. Output Voltage delivered to filter of typical rectifier circuits, refer to Technical Bulletin.

SPECIAL PURPOSE

UX-874	Voltage Regulator	UX	5 5/8"	2 3/16"	Designed to keep output voltage of B-Eliminators constant when different values of "B" current are supplied.	Operating Voltage ... 90 Volts D. C. Starting Voltage ... 125 Volts D. C. Operating Current ... 10-50 Milliamperes
UV-876	Current Regulator (Ballast Tube)	Mogul	8"	2 1/16"	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage.	Operating Current ... 1.7 Amperes Voltage Range ... 40-60 Volts
UV-886	Current Regulator (Ballast Tube)	Mogul	8"	2 1/16"	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage.	Operating Current ... 2.05 Amperes Voltage Range ... 40-60 Volts

FOR AMATEUR AND EXPERIMENTAL TRANSMITTING USE

Type	Use	Base	Maximum Overall Dimensions Height	Maximum Overall Dimensions Width	Filament Terminal Volts	Filament Current Amperes	Voltage Amp. Factor	Normal Plate Volts	Approx Grid Bias Volts	Approx. Screen Volts	Maximum Plate Current Amperes	Maximum Plate Dissipation Watts	Normal Power Output Watts
UX-852	Oscillator or R. F. Amplifier	UX	8 3/4"	6 1/8"	10.0	3.25	12	2000	250	—	0.10	100	75
UX-865	Oscillator or R. F. Amplifier	UX	6 1/4"	2 3/16"	7.5	2.0	150	500	75	125	0.06	15	7.5
UX-866	Half-Wave Rectifier	UX	6 5/8"	2 7/16"	2.5	5.0	Maximum Peak Inverse Voltage ... 5000 Volts Maximum Peak Plate Current ... 0.6 Ampere Approximate Tube Voltage Drop ... 15 Volts						

THE CATHODES ARE CAREFULLY SPRAYED TO GIVE THEM A UNIFORM COATING OF THE ELECTRON EMITTING MATERIAL

RCA INSTITUTES INC