

Cunningham RADIO TUBES

BULLETIN

Type CX-322 Tube SCREEN GRID AMPLIFIER



1—Type CX-322 is a distinct departure from the conventional type of three element radio tube. The unusual characteristics and performance obtained from this tube are made possible by the introduction of a second grid, of novel design, which extends between the usual grid and the plate, and is also carried over outside the plate. Thus the plate is completely shielded or screened from the control grid by the second grid.

If the plate is left disconnected, and the screen grid used as the plate electrode, the tube operates in a manner exactly similar to the usual three element tube, having an amplification factor of 6.5 and a plate resistance of 15,000 ohms.

In operation as a four element tube a voltage of approximately 45 volts is applied to the screen grid, and a higher voltage (90 to 135 V.) is applied to the plate. The effect of this method of use upon the performance of the tube is explained in sections 6 to 8 below, dealing with the use as an amplifier.

2—BULB

The standard S-14 bulb (same as that used with type CX-301A) is used except that provision is made for a connection to the control grid on the top of the bulb, as indicated in the cut.

3—BASE

Standard CX. The usual grid terminal does not connect to the control grid as is the case with three element tubes, but to the screen grid.

4—FILAMENT

The filament provided in the CX-322 is rated at 3.3 volts, .132 amperes. For use with five volt tubes see rheostat recommendations, Section 12. When used as an R. F. amplifier only, the filament may be operated from an A. C. source by means of a step down transformer.

5—ELEMENTS

The control grid, cylindrical in form, is arranged in a manner similar to that of the CX-299, except that the connection to this element is brought out at the top of the bulb. The screen grid is interposed between the plate, which is also cylindrical, and the control grid, completely surrounding the plate as described above, and eliminating almost completely all electrostatic capacity between control grid and plate. The plate is larger in diameter than that used in type CX-299.

The somewhat complicated mechanical structure requires unusual skill in design to secure a rigid structure. The design has been very carefully worked out and the tube is more rugged than the average type of receiving tube.

6—USE AS DETECTOR

The tube may be used as a detector with grid leak and grid condenser or with grid bias. Resistance coupling with connections similar to those shown in the diagram on page 31, is recommended as giving the most satisfactory frequency characteristics because of the high internal resistance of the tube.

7—USE AS A RADIO FREQUENCY AMPLIFIER

This tube has been especially designed for use as an R. F. amplifier. When so used the most important advantage gained is elimination of all feed back through coupling between grid and plate, due to capacity between these elements. It is also possible to obtain higher voltage amplification per stage, 25 to 50 in the broadcast range as compared with the usual range of 5 to 12 per stage with three element tubes.

In the operating range the plate current does not vary appreciably with changes in plate voltage, this being due also to the screening effect of the second grid. As a result the amplitude of the plate current change, caused by a signal voltage impressed on the grid is scarcely affected by an increase in load resistance. Thus it is of advantage to use a very high resistance or impedance in the plate circuit, in order to obtain high voltage amplification.

The voltage amplification depends only upon two factors:

A—The mutual conductance of the tube, which determines the amplitude of the plate current change, resulting from a signal voltage impressed on the control grid, and—

B—The load impedance. The voltage across the output load is directly proportional to the local impedance, since the amplitude of the signal current, with moderate loads, remains unchanged with an increase in impedance. This is unlike the condition with three element tubes, where an increase in load resistance results in a decrease in the amplitude of the signal current.

At low radio frequencies, 50 to 100 kilocycles, it is possible to build up a very high load impedance by using a tuned plate circuit, and a voltage amplification of 200 per stage is obtainable. At broadcast frequencies it is not possible to obtain a sufficiently high load impedance to realize maximum voltage amplification, and the values quoted above represent average results (25 to 50 per stage).

Since the voltage amplification depends only upon the load impedance and mutual conductance it may be quickly computed when these values are known. The voltage amplification obtained with a load impedance of 100,000 ohms, using a tube having a value of mutual conductance of 350 micromhos (.00035 mhos.).

$$A_v = 100,000 \times .00035 = 35 \text{ per stage.}$$

With 250,000 ohms. $A_v = 250,000 \times .00035 = 87 \text{ per stage.}$

It is possible to obtain the desired high load impedance by use of a tuned circuit connected in series with the plate, but it may be preferable to use a transformer connection with a ratio of 1:1 or slightly lower so that low frequency disturbances do not reach the grid of the succeeding tube and to facilitate the use of ganged condensers for uni-control. Both connections are shown in the circuit diagrams.

Although the internal shielding prevents feed back thru the tube interelectrode capacities, this is only one source of coupling between stages, and it is also necessary to shield the input circuit from the output circuit. The amount of shielding necessary will depend upon the voltage amplification per stage and the circuit design. A metallic shield enclosing each tuned stage

is usually sufficient, as indicated in the circuit diagram. It may be necessary, if the voltage amplification is high, to place a metal cap over the tube, extending to the base, and connected to ground. Clearance for the grid connection must be provided at the top.

8—USE AS AN AUDIO FREQUENCY AMPLIFIER

The tube may be used as an audio frequency amplifier with resistance coupling, the connections being the same as when the tube is used for radio frequency amplification, except that the screen grid voltage should be lowered to compensate for the voltage drop in the load, unless a high plate voltage is available. With this connection a voltage amplification of 35 per stage may be readily obtained with perfectly flat frequency characteristics down to 50 cycles and below (the lower limit is fixed only by the size of the blocking condenser); and extending on the high frequency and well above 10,000 cycles.

9—OPERATING CONDITIONS

Filament Volts	3.3
Filament Amperes	.132
Control Grid Volts (Average)	-1.5
Screen Grid Volts "	45.
Plate Volts	90 to 135

10—AVERAGE TUBE CHARACTERISTICS

Plate Voltage	135	135
Grid Voltage	-1.5	-1.5
Screen Grid Voltage	45	67.5
Amplification Factor	300	290
Plate Resistance (ohms)	850,000	600,000
Mutual Conductance (Micromhos)	350	480
Plate Current (Ma.)	1.5	3.3

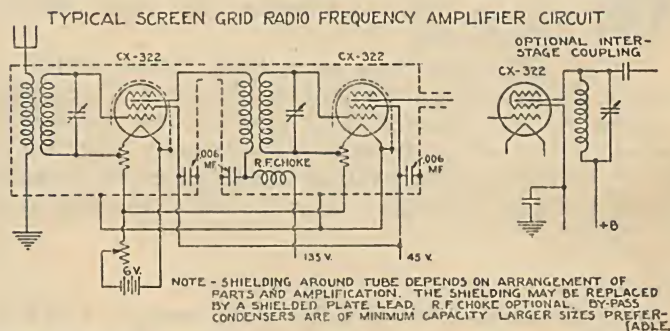
11—INTERELECTRODE CAPACITY

Plate to control grid (max)	.025 mmf.
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12—RHEOSTAT RECOMMENDATIONS

For use with 4.5 volt dry cells use a 20 to 30 ohm rheostat.

For use with 5 volt tubes; connect a fixed resistance of 15 ohms in series with the filament of the tube. It may then be connected in parallel with other 5 volt tubes, operating from a common rheostat. If placed in the negative lead a tap at 10 ohms will provide -1.3 volts bias for the control grid.



TYPICAL SCREEN GRID AUDIO FREQUENCY AMPLIFIER CIRCUIT

