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Application of the Four-Electrode Receiving Tube (UX-222)

By Alan C. Rockwood
and
B. J. Thompson
Research Laboratory, General Electric Co.

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PART II

IT will be of interest to consider the actual performance of the UX-222 and to compare this with the UX-201-A. At broadcast frequencies in carefully designed amplifiers using the UX-222 amplifications of 40 to 50 per stage have been obtained with complete stability. With the UX-201-A in neutralized circuits and with the best transformers, an amplification of about 10 per stage is the practical limit. At a frequency of 20,000 kilocycles (15 meters) amplification of 10 to 15 per stage is obtained from the UX-222. It is practically impossible to operate the UX-201-A as a radio-frequency amplifier in the short-wave bands, because of oscillation even with careful neutralization. In the intermediate frequencies, 40 to 100 K.C., amplification from 100 to 150 per stage may be obtained from the UX-222 while 20 to 40 is the best that may be done with the UX-201-A.

While 45 volts is the recommended voltage for the screen-grid tube for all such uses as those just described, increasing it to 67.5 volts will usually result in a slight increase in amplification although this is not advised in most cases as it results in increased plate current. While 90 volts will usually be a satisfactory plate voltage, the use of 135 volts results in increased amplification and better performance; this voltge should not be exceeded. In nearly all cases a negative control grid bias of about 1.5 volts should be used.

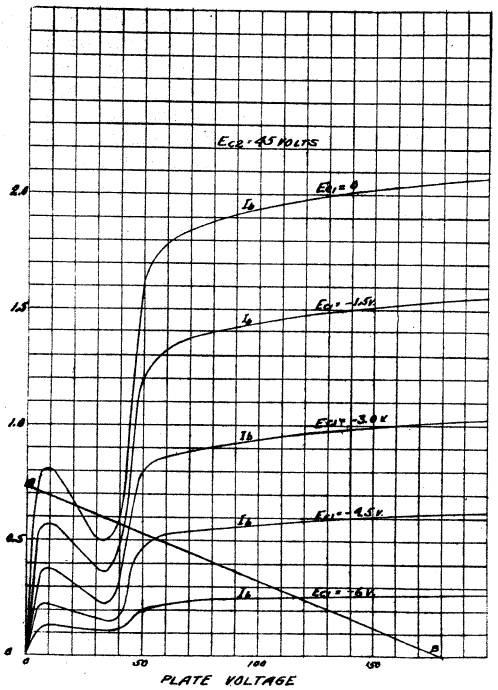

FIG. 15

Where resonant impedances are used in the load circuit the plate resistance of the tube operating into the load acts as a shunt across this load, and hence affects the sharpness of the tuning, or the selectivity. The UX-222, with a plate resistance of 850,000 ohms, acts as a very high resistance shunt, and consequently gives greater selectivity than a tube having lower plate resistance.

Another important use of

the UX-222 as a screen-grid tube is in resistance-coupled amplifiers. Here again it is possible to realize considerable amplification by the use of high impedance loads, while the low feed-back capacity makes possible amplification at higher frequencies than with three-electrode tubes.

It must not be supposed, as might at first seem the case, that by using an 800,000-ohm resistance in the load circuit, an amplification of 150 per stage will be obtained. To do this would require over 1300 volts B supply due to the high d.c. voltage drop in the load resistance. By examining Fig. 15, the effect of this will be seen. This diagram presents a family of plate characteristics of the UX-222 taken at 45 volts on the screen. If it be assumed that the B supply voltage is 180 volts and that the load resistance is to be 250,000 ohms, the line A—B represents the voltage-current curve for the load, passing through zero current at 180 volts. The intersection of this load resistance line with the plate characteristic of the tube indicates the operating voltage and current of the tube for the grid bias corresponding to the curves used. It will be seen that, with all biases of

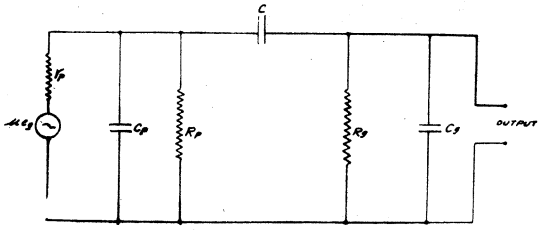

FIG. 17

less than 4.5 volts negative, the tube operates at such a low plate voltage that the amplification factor is negligible. With negative 6 volts bias on the control grid the mutual conductance of the tube has dropped off so much that the amplification is only about 40 per stage.

Fig. 16 shows a similar family of curves taken with 22.5 volts on the screen. It will be noticed here that the tube operates satisfactorily with only 1.5 negative volts grid bias. Under these conditions, the amplification is again about 40 per stage.

Fig. 17 shows an equivalent circuit for a resistance-coupled amplifier. Here:

$$C_p = C_{pg} + C_{pf} + C_{ps}$$

when C_{pg} is the plate-grid capacity of the tube, C_{ps} the plate-screen capacity, and C_{pf} the plate-filament capacity, all including wiring capacities. Also:

$$C_g = C'_{gs} + C'_{gt} + C'_{gp}\,(A_v + 1)$$

where C'_{gs} is the capacity between grid and screen of the

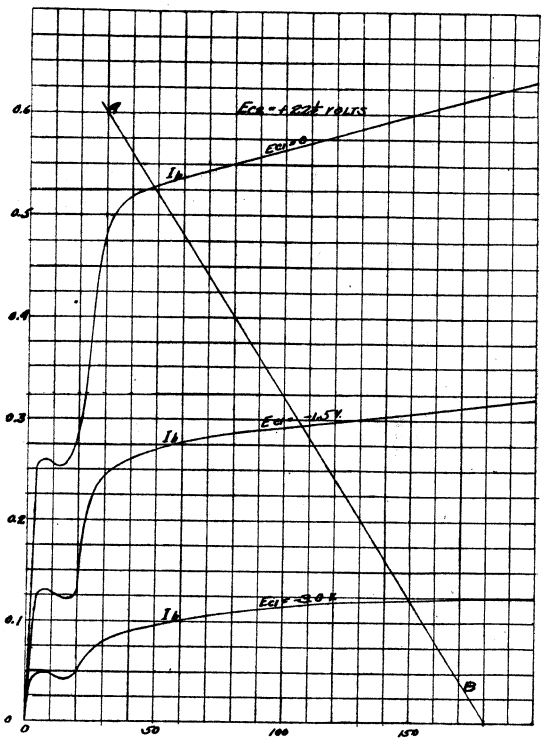

FIG. 16

next tube in the amplifier, C'_{gf} the grid-filament capacity, C'_{gp} the grid-plate capacity, and A_v the voltage amplification, all of the next tube. C is the blocking condenser, while R_p and R_g are the plate and grid coupling resistors. The value C_g is the effective grid capacity shunted across the load resistance of the preceding stage and serves to reduce the amplification of the high frequencies, due to its by-passing effect. The gain in fidelity due to the reduction of the effective grid-plate capacity of the amplifier tubes will be appreciable. The UX-222, for example (C_{pg} = 0.025 mmfd. max.) will have a value for C_g of 9 mmfd. as compared with that of 200 mmfd. for the UX-240 (C_{pg} = 9 mmfd.)

It must be understood that these capacity values neglect the external portion of C_{pg} due to capacity coupling between the plate and grid circuit wiring. It is easy, unless care is taken in laying out the parts, to set up an audio-

TABLE NO. 2

SCREEN-GRID RESISTANCE-COUPLED UX-222

Filament Voltage	(E_f)	3.3	
B Supply Voltage	(E_b)	180	
Series Loud Resistance	(R_p)	250,000	Ohms
Control-Grid Voltage	(E_{c1})	—1.5	
Screen-Grid Voltage	(E_{c2})	+22.5	
Plate Current	(I_p)	0.3	mA.
Plate Resistance	(r_p)	2	Megohms
Mutual Conductance	(g_m)	175	Micromhos
Amplification Factor	(u)	350	

TABLE NO. 3

SPACE-CHARGE-GRID UX-222

Filament Voltage	(E_f)	3.3	
B Supply Voltage	(E_b)	180.	
Series Load Resistance	(R_p)	250,000	Ohms
Control-Grid Voltage	(E_{c2})	0—$\frac{3}{4}$—1$\frac{1}{2}$	
Space - Charge - Grid Voltage	(E_{c1})	+22.5	
Plate Current	(I_p)	0.3	mA.
Plate Resistance	(r_p)	150,000	Ohms
Mutual Conductance	(g_m)	400	Micromhos
Amplification Factor	(u)	60	

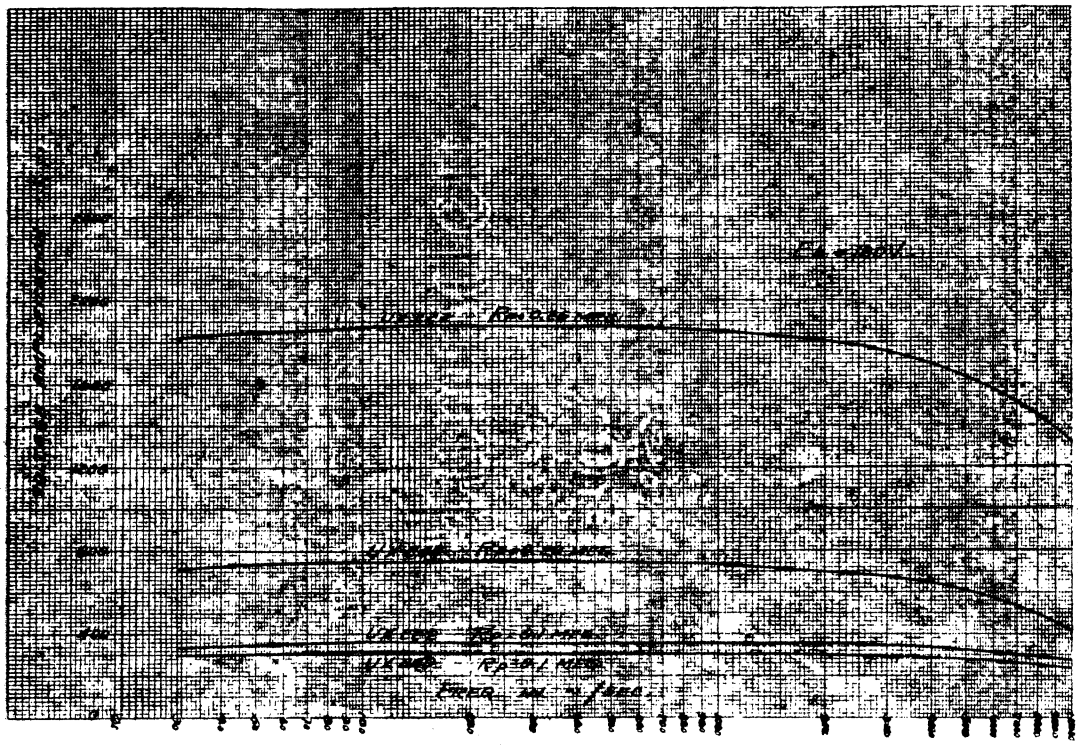

FIG. 18

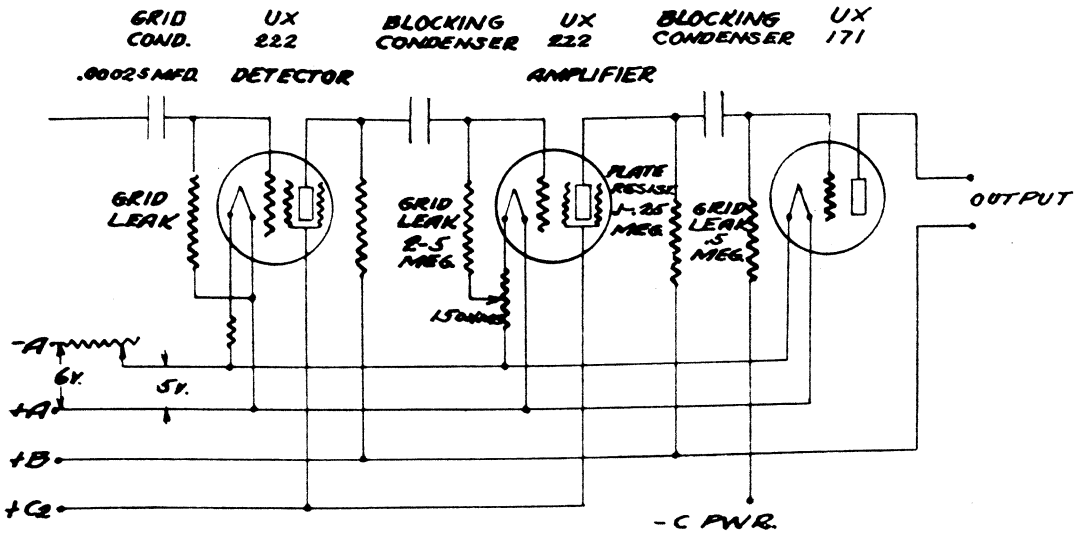
GRID COND. .0002 SMFD.
UX 222 DETECTOR
BLOCKING CONDENSER
UX 222 AMPLIFIER
BLOCKING CONDENSER
UX 171
GRID LEAK
GRID LEAK 2-5 MEG.
PLATE RESIST. 1-.25 MEG.
GRID LEAK .5 MEG.
OUTPUT
-A
6V.
5V.
+A2
+B
+C2
-C PWR.

FIG. 19

frequency amplifier that will have an input capacity of 50 to 100 mmfd. as a result of a C_{pg} of approximately 1 mmfd. in the circuit external to the tubes. In Fig. 18 is shown a comparison of two such amplifier circuits using the same open layout in each case with reasonable precautions to avoid coupling between tubes. The improvement in fidelity resulting from the characteristics of the UX-222 is evident, as well as is the increased voltage amplification. If greater fidelity is desired the use of shielded amplifier stages is desirable.

Fig. 19 is a circuit diagram for a two-stage amplifier using UX-222's with a UX-171 output tube. The voltages and constants given in Table No. 2 (page 42) are recommended for ordinary audio amplifiers. Increased amplification may be obtained by using a higher B-supply voltage and making the proper adjustment of the screen voltage.

Resistance-coupled amplifiers for special purposes have been built using the UX-222, and then give satisfactory amplification at more than 50,000 cycles.

AS A SPACE-CHARGE-GRID TUBE

SPACE-CHARGE-GRID tubes are the result of the work of Langmuir in this country and by Schottky and Barkhausen abroad. While, as before mentioned, the UX-222 was not designed primarily for this purpose, it may be operated as a space-charge tube with satisfactory results.

If a two-grid tube is connected, as shown in Fig. 20, with the inner grid at a positive voltage and the outer grid at a negative bias, electrons are drawn away from the filament by the inner grid and thrown out into the space between the two grids. Most of these electrons come to a stop

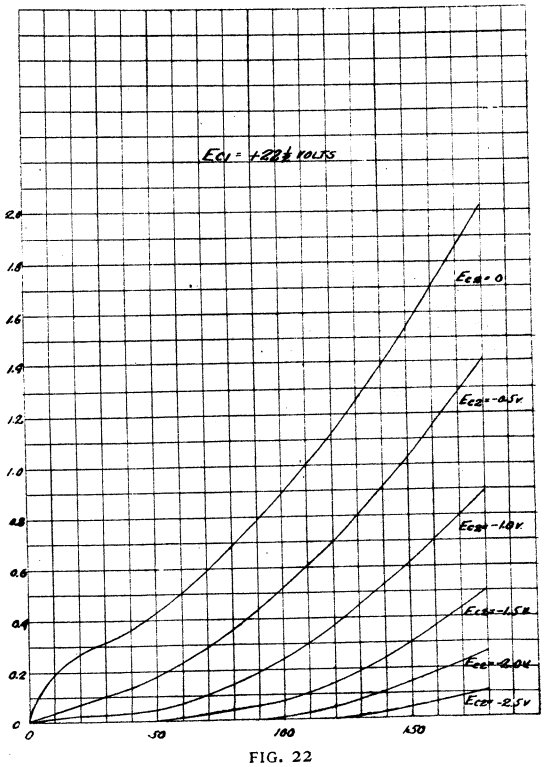

FIG. 22

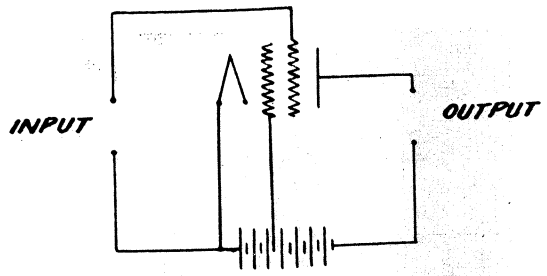

FIG. 20

very close to the outer grid, and then fall back to the inner grid. The ones which fall back are replaced by others, so that there is a continuous cylinder of electrons very close to the outer grid. This has the effect of a cathode placed very close to the outer grid, giving low plate resistance. The amplification factor between the outer grid and the

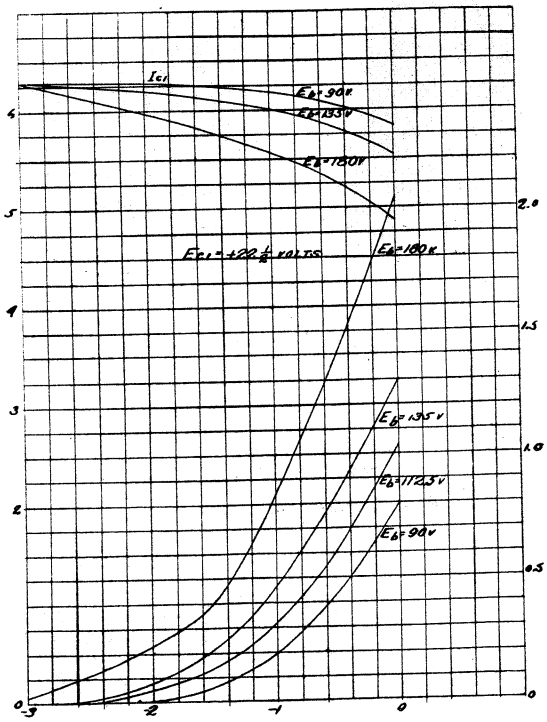

FIG. 21

plate is only slightly affected by this, so that the result is high mutual conductance.

Space-charge tubes have been popular in Europe where low operating voltages and a small number of tubes were desired. In America, where there is a demand for the multi-tube receivers, and where power tube operation of loud speakers has necessitated high plate voltage, there has been little demand for such a tube.

The UX-222 operated as a space-charge tube is somewhat different from many of the European tubes. It is a high amplification factor tube requiring moderately high voltages to operate it. Its advantage is higher gain per stage

than is practicable with three-electrode tubes, due to higher mutual conductance.

Figs. 21 and 22 give the static characteristics of the UX-222 space-charge tube. They differ little from those of three-electrode tubes, with the exception of the added inner grid current, and the high mutual conductance for a tube of such a high amplification factor.

The UX-222 space-charge tube may be operated the same as any three-electrode tube having high amplification factor. The most important use for such tubes is in resistance- or impedance-coupled audio amplifiers. Such an amplifier is shown in Fig. 23. A B-supply voltage of 135 to 180 volts with a coupling resistance of 0.1 to 0.3 megohm is recommended. Suggested operating conditions and the resulting tube constants are given in Table No. 3 (page 42)

Due to the high capacity between outer, or control, grid and plate, the amplification of such an amplifier falls off at high frequencies. This is shown in Fig. 24, which is a curve of amplification against frequency for the amplifier of Fig. 23 and Table No. 3. The gain in amplification over the UX-240 is also shown.

Over one hundred circuits are known to have been developed using the space-charge tube in various combinations of reflex, double regenerative, and similar circuits. Among these are included a large number making use of the negative change of the space-charge grid current with the plate current upon variation of control grid bias. It is doubtful, however, if the greater part of these circuits produce the results as effectively or economically as less involved circuits using a greater number of lower priced tubes.

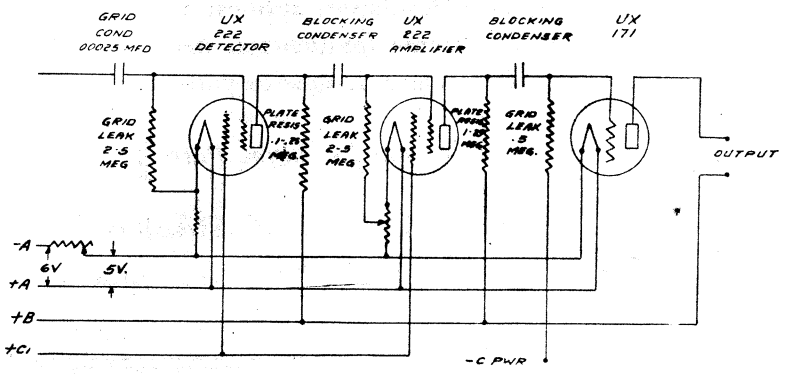

FIG. 23

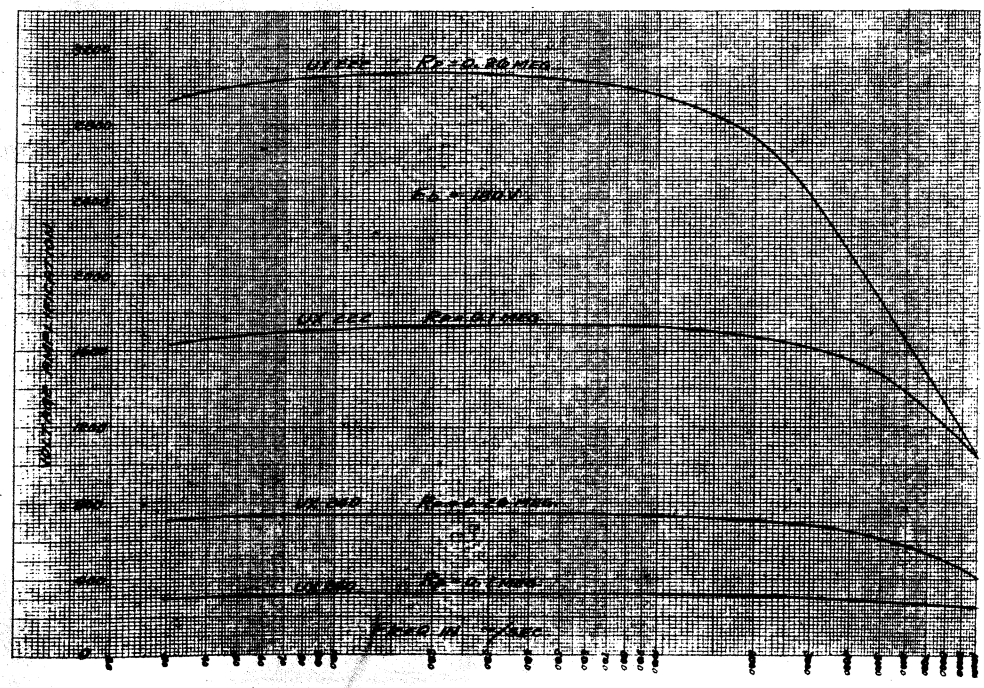

FIG. 24

RADIOTRON UX-250

The Newest Power Radiotron, with a Maximum Undistorted Power Output of 4650 milliwatts

The UX-250 has a lower plate resistance than power amplifier Radiotrons heretofore offered. This low plate resistance is particulary desirable for use with present day loudspeaker driving mechanisms which usually have a relatively low impedance.

The characteristics of the UX-250 are as follows:

	Recommended				*Maximum*	
Plate Voltage	250	300	350	400	450	Volts
Negative Grid Bias	45	54	63	70	84	"
Plate Current	28	35	45	55	55	Milliamp.
Plate Resistance (A-C)	2100	2000	1900	1800	1800	Ohms
Mutual Conductance	1800	1900	2000	2100	2100	Micromhos
Volt. Amplification Factor	3.8	3.8	3.8	3.8	3.8	.....
Max. Undistorted Output	900	1500	2350	3250	4650	Milliwatts

Filament.....7.5 Volts.....1.25 Amperes
Max. Overall...Height 6¼ in...Diameter 2 11/16 in.
Base.....Large RCA Standard UX

RADIO CORPORATION OF AMERICA
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RCA Radiotron

MADE BY THE MAKERS OF THE RADIOLA