TYPE CX-301A

CX-301A, the most popular and widely used type in the Cunningham Radio Tube line, is a high vacuum receiving tube of the general purpose type. The high mutual conductance and low plate impedance of this model are responsible for the very excellent results obtained when used either as radio frequency amplifier, detector or audio frequency amplifier. It is widely used as a loud speaker supply tube of moderate output.

CX-301A is electrically the same as C-301-A, but is mounted on the large CX standard base instead of the old type navy base. No change whatever in tube characteristics was made when the new base was adopted. Compared to C-301A production of 1923, CX-301A has higher efficiency, resulting in improved performance. The improved efficiency results from a twenty percent increase in mutual conductance.

The CX-301A filament is of the thoriated tungsten type, rated at 5 volts, .25 ampere. The emission at rated voltage is well above that ordinarily required in normal operation and when the tube is used on moderate plate voltages, the filament voltage can be lowered to 4.5 or 4.0 volts without impairing the efficiency and with a resulting increase in the life of the tube. A 6 volt storage battery of the lead cell type or a 4.8 or 6 volt Edison battery affords the most convenient source of filament current, except with one or two tube sets where dry cells may be used.

The low filament current required by the CX-301A tubes makes it possible to operate five tubes or more from a single rheostat of 2 ohms resistance. This rheostat may be used as a master control to reduce the filament terminal voltage of all tubes in the set to 5 volts and separate rheostats can then be used to further reduce the filament voltage on any individual tube, as is often customary for volume control purposes. A circuit diagram using this arrangement is shown in Fig. 4, Plate 25. When a single tube is operated from a separate rheostat, the 10 ohm size is most convenient although for some purposes a rheostat resistance up to 25 ohms may be desirable. In operating a larger number of tubes from the same rheostat, proportionately lower values should be chosen.

With the thoriated tungsten filament, the life of the tube is usually ended by a rapid decrease in electron emmission, rather than by actual burnout of the filament.

The exceptional operating efficiency of CX-301A is attained by taking precautions to attain and insure an unusually high vacuum, as even a slight trace of gas impairs the filament emission. Several chemicals which ordinarily give the bulb a uniform "silver" color are introduced in our patented manufacturing processes to obtain this nearly perfect vacuum. This appearance of the bulb is not an indication of the merits of the tube and cannot be taken as a guide in selecting tubes. The presence of a "rainbow" marking, which sometimes has the appearance of a burned spot, is characteristic of many CX-301A tubes.

This spot is produced in the factory processes and is not an indication that the tube has been used, reactivated, overloaded or has any special features.

While the materials used in the bulb insure the maintenance of a high vacuum throughout the life of the tube at rated voltages, under some conditions of overload or abuse, slight impairment of the vacuum may result and cause a decrease in electron emission. This is often the case when the tube is used as a rectifier on heavy load currents or at plate voltages in excess of 135 volts. For rectifier service, CX-313 or 316-B rectifier tube should always be used.

In taking emission readings, it is common practice to connect the grid and plate together applying 50 volts anode voltage. When such readings are taken, this voltage should be applied only for a few seconds and the applied voltage should never exceed 50 volts. The use of higher voltages in at least one commerical test set damages the tube and frequently causes the emission current to drop to a value below passing, even though it is applied for only a few seconds.

USE AS A DETECTOR

CX-301A as a detector is quiet in operation and does not require critical adjustment of plate or filament voltage. Any plate voltage between 22.5 and 67.5 volts may be used and, while the filament temperature need not be carefully adjusted, it is usually advisable to turn the detector tube up to rated voltage in order to avoid microphonic action which sometimes occurs when the filament is heated to less than normal operating temperature. The use of a cushioned socket for the detector tube is always good practice and especially so at present in view of the tendency to use power amplifier tubes in the output stage. The greater intensity of the sound vibrations from the speaker, with power tubes, subjects the detector to increased vibration and, at times, results in "singing" or "howling." The most satisfactory cushioning material is very soft sponge rubber.

A grid condenser of .00025 MF capacity with a grid leak having resistance of 2 megohms is recommended. Higher grid leak values give better signal strength on weak signals but may cause blocking or distortion on strong local stations.

USE AS AUDIO FREQUENCY AMPLIFIER

The low output impedance of the CX-301A results in excellent performance in the audio stages especially when using the improved types of audio transformers. It is general practice to use 90 volts plate with a grid voltage of -4.5 volts. However, in all except the last audio stage, lower voltages may be used without noticeably affecting the quality and with a resultant marked saving in "B" battery current. The extent of this saving in "B" battery consumption is shown in the following table:

"B" BATTERY CURRENT AND POWER CONSUMPTION

"B" Battery Voltage	"C" Battery Voltage	Plate Current	"B" Power Consumption
Volts	Volts	Milliamperes	Milliwatts
45	-1.5	.9	4
67.5	-3.0	1.5	10
90	-4.5	2.0	18
135	-9.0	2.5	34

The use of the lowest voltage indicated in the above table does not result in a decrease in voltage amplification and should be taken advantage of in the construction of portable receivers where the very small "B" batteries used are expensive because of their limited capacity.

The CX-301A tube is satisfactory for use in resistance coupled amplifiers, being relatively free from blocking or "stuttering" trouble sometimes encountered in this type of circuit. The low output impedance is also advantageous since the condensers and coupling resistors need not be as large for reproduction of low pitched audio tones as with high impedance tubes.

USE AS A POWER AMPLIFIER

In using the CX-301A tube as a loud speaker supply tube, best results are obtained with a plate voltage of 135 volts, but this voltage should not be used unless the recommended grid bias of 9 volts is added. If desired, two CX-301A tubes may be used in parallel on 135 volts, the power output equalling that obtained from CX-112 at 135 volts plate. When using a single CX-301A tube at 135 volts plate some improvement in tone quality, with slight sacrifice in power output, may be obtained by decreasing the grid biasing voltage to -7.5 volts.

It should be remembered that as "B" battery terminal voltages drop during the life of the batteries, the power output decreases since the "C" battery voltage remains constant. The remedy is to decrease the bias voltage 1.5 volts for every 12 volts drop in plate battery voltage. If this is done, the "B" batteries may be used until their terminal voltage has dropped to between 30 and 35 volts per 45 volt block, when the poorer ones should be discarded.

It is recommended that either Types CX-112 or CX-371 be used as the power amplifier to feed the loud speaker where increased volume with undistorted tone quality is desired.

USE AS RADIO FREQUENCY AMPLIFIER

CX-301A finds its widest use in radio frequency amplification, and is especially desirable because of its high mutual conductance and high input impedance. Its performance is noticeably superior to many of the competitive

so-called "A" tubes. Relative measurements made in our laboratory in a typical one stage neutrodyne or tuned radio frequency receiver gave the following average comparative results:

Tube Type	Input Voltage Millivolts	Input Voltage to Next Stage Millivolts	Voltage Amplification per Stage	Relative Efficiency
Cunningham CX-301A	.1	2.00	20.0	100%
Competitive Types, Lowest	.1	.64	6.4	32%
" " Highest	.1	1.30	13.0	65%

Difference in tube performance of the order shown in the above tabulation is evident when listening to distant stations, but will not be noticed in tuning local stations.

Many factors enter into tube quality and performance. Plate current and emission readings indicate merely that a tube is in operatable condition and give no indication of the quality of performance. A tube may have entirely satisfactory values of mutual conductance, plate current, plate impedance and amplification constant, and yet have a low input impedance. Tests in our laboratory of such tubes have shown that the low input impedance reduces the voltage amplification in the average radio frequency amplifier to 30% of the normal gain and at the same time the selectivity of the tuned circuit is noticeably impaired. A given signal coming in over a range of 20 kilocycles with CX-301A could be heard over a range of 50 kilocycles with a tube of low input impedance. The volume must be turned up equal to that obtained with CX-301A to demonstrate this decrease in selectivity. High tube input impedance can only be obtained by using extreme care, not only in the selection of materials used in the tube, but also, in certain of the delicate manufacturing processes.

In radio frequency amplification it has been common practice to use a "B" voltage of 90 volts without a biasing battery, and while this results in maximum amplification, it is somewhat wasteful of current. A decrease in this voltage to 67.5 or 45 volts or the addition of a "C" battery will result in a large saving of "B" battery current, together with improved tone quality on local programs. Two CX-301A tubes as radio frequency amplifiers require 12 milliamperes plate current with 90 volts "B" voltage, 7.0 milliamperes with 67.5 volts and only 3.4 milliamperes when the voltage is reduced to 45 volts. The use of lower plate voltages will often more than double the service obtained from dry cell "B" batteries, and will also aid in securing quiet, hum free service from "B" eliminators, especially those having limited current output.

The decrease in radio frequency amplification obtained from the tube when the "B" battery voltage is dropped from 90 volts to 67.5 is only moderate, since plate impedance rises only about 1,500 ohms or from 8,000 to 9,500 ohms. An equivalent saving in "B" battery current may be obtained by us-

ing the proper "C" battery voltage. When the full "C" voltage of 4.5 volts is provided, as normally recommended with 90 volts plate, the "B" battery current drops from 6 milliamperes per tube to 2 milliamperes, a saving of 67%. The use of a "C" battery voltage less than the rated value may be preferred. A convenient method, and one which does not introduce coupling between stages, is to obtain the grid bias from the 1 volt drop in the filament circuit. A fixed resistance of 4 ohms may be added in the negative filament lead to each radio amplifier and the grid return lead connected to the battery side of this resistance. When the rated current of .25 ampere is flowing, a negative grid voltage of 1 volt will be obtained from this resistor. The saving in plate current is only 1 milliampere but the input impedance will be very greatly increased, resulting in decreased damping of the input circuit. This will increase the receiver selectivity and sensitivity, by offsetting the effect of increased plate impedance.

When tuned circuits are used as the coupling between successive radio frequency stages, the tube characteristics play an important part in determining not only the voltage amplification but also the degree of selectivity. Each tuned stage feeds directly into the input of a radio frequency amplifier tube, and a low tube input impedance is equivalent to adding a resistance in parallel with the tuning condenser, with resultant broadening of the tuning and a decrease in the voltage built up across the condenser by a given induced signal voltage. This effect may be reduced to a minimum by means of the method just explained, - the use of at least a small grid bias. The tube output resistance is coupled into the succeeding tuned stage to an extent determined by the amount of coupling between stages. This has the effect of increasing the resistance or damping of the tuned circuit and accounts, in a large measure, for the general practice of using a fewer number of turns in a coupling coil than the proper number for maximum energy transfer. The output impedance of the CX-301A is maintained at a consistently low value while the input impedance is uniformly high. These two factors account for the uniform success and popularity of CX-301A as a radio frequency amplifier.

CUNNINGHAM RADIO TUBE
TYPE CX-301A

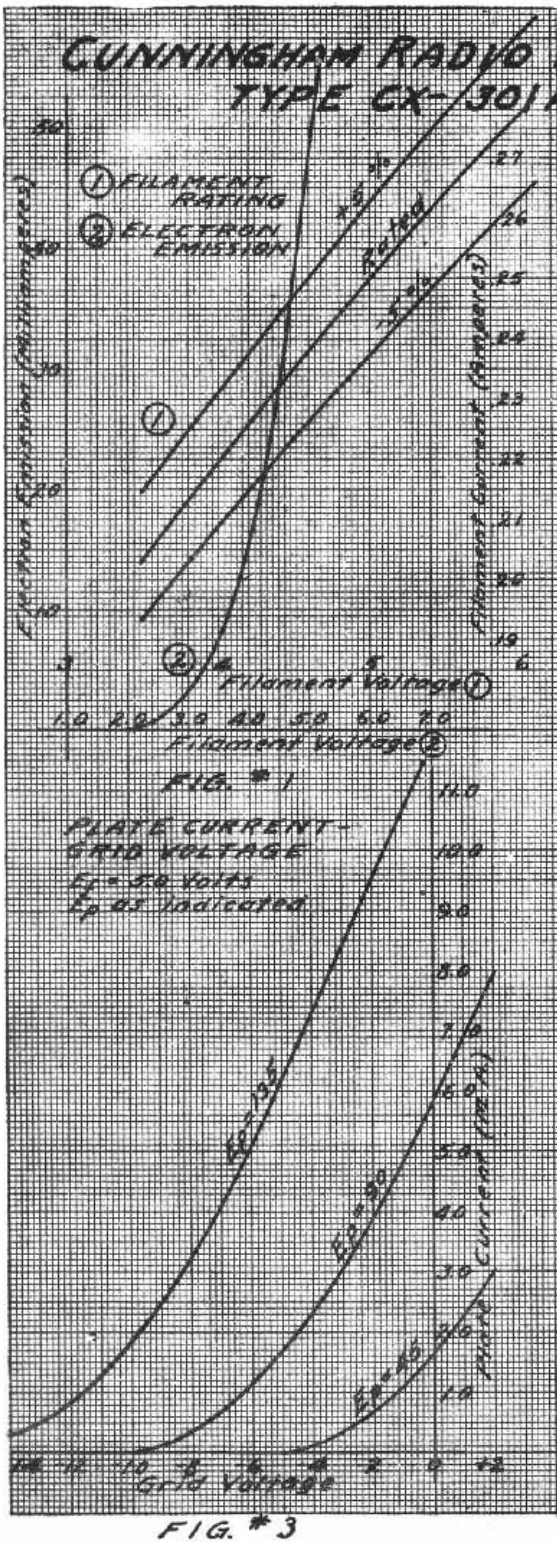

FIG. #1

FIG. #3

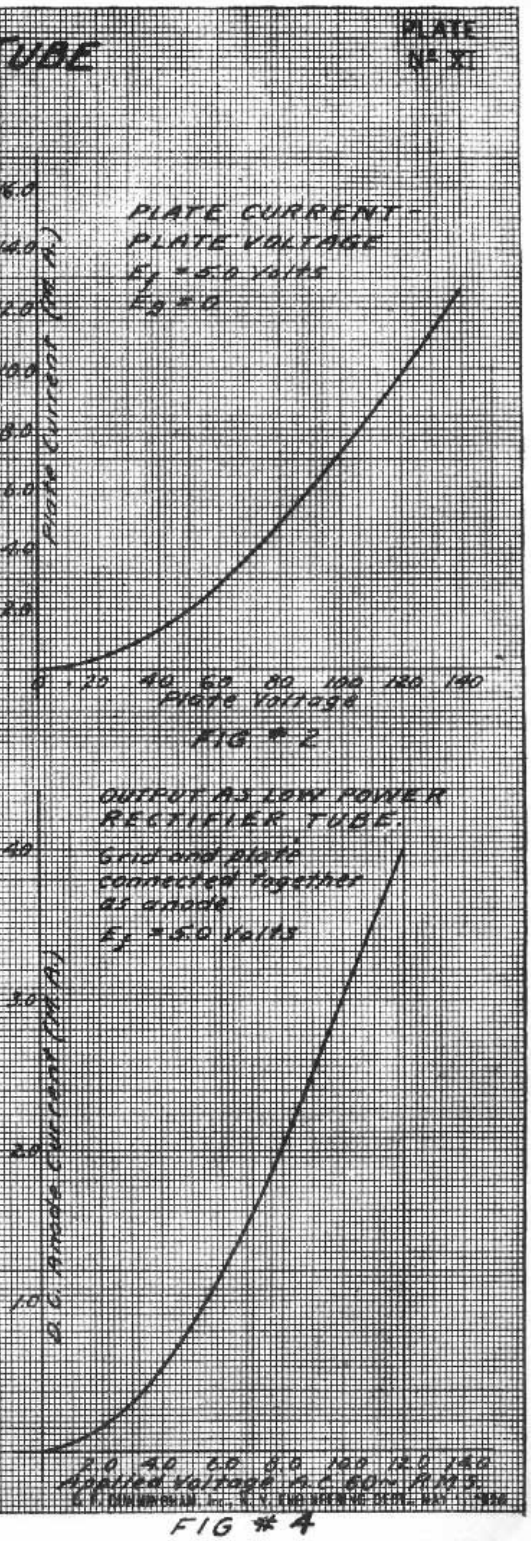

FIG. #2

FIG #4

CUNNINGHAM RADIO TUBE
TYPE CX-301A

PLATE
Nº XII

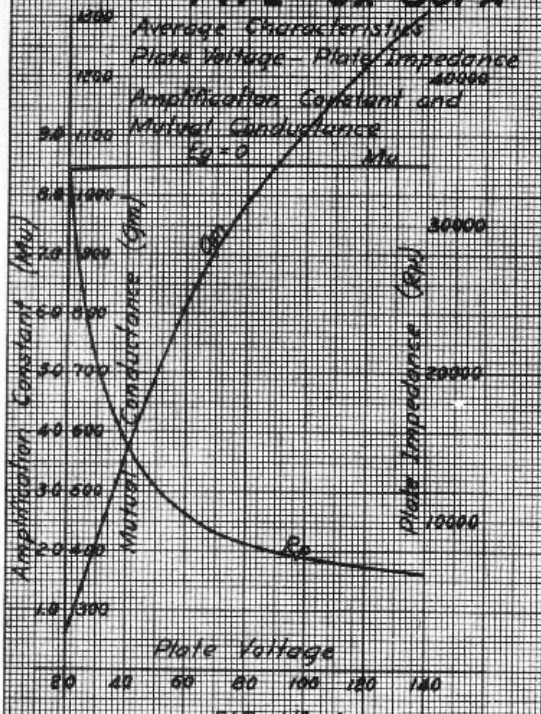

FIG. Nº 1

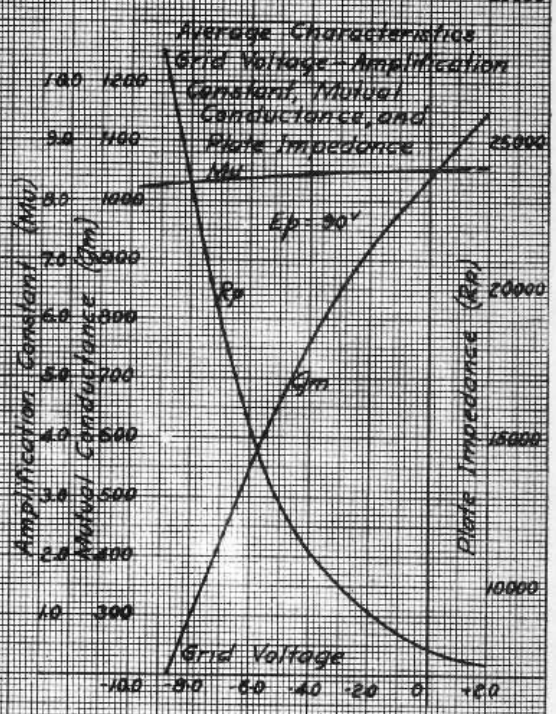

FIG. Nº 2

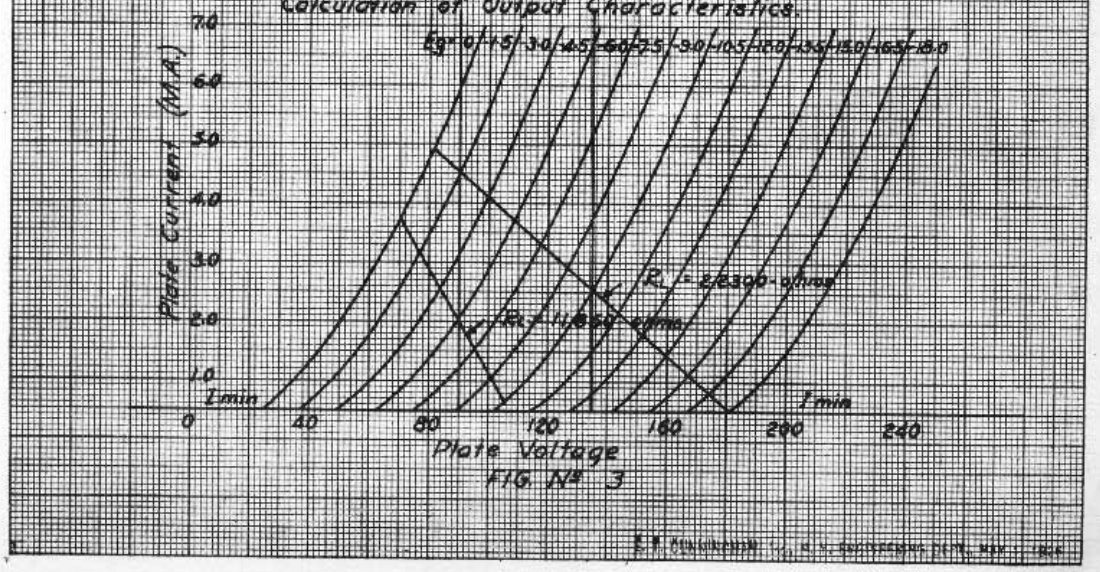

FIG. Nº 3