RCA MANUFACTURING COMPANY, INC.

A RADIO CORPORATION OF AMERICA SUBSIDIARY

Harrison, New Jersey

RCA RADIOTRON
DIVISION

APPLICATION NOTE No. 61
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APPLICATION NOTE ON THE CONVERSION OF A 6L6 PLATE FAMILY TO NEW SCREEN VOLTAGE CONDITIONS

In order to determine the performance of a tetrode or pentode from its plate characteristics, it is necessary to have a suitable plate family for every screen voltage of interest. The well-known Conversion-Factor Chart can be used to convert a tetrode or pentode plate family to new screen-voltage conditions. However, when the Chart is used for this purpose, the useful range of a converted plate family is curtailed for decreases in screen voltage; moreover, the accuracy of the converted family is good only for small changes in screen voltage. When the Chart is used to convert the plate family of the usual tetrode to a new screen-voltage condition, only sections of high plate voltage should be converted, because of errors introduced at low plate voltages by secondary-emission effects.

Although the 6L6 is a tetrode, it may be operated at low plate and control-grid voltages without secondary-emission effects; consequently, the Conversion-Factor Chart may be applied to a 6L6 plate family, provided the range of the converted family is large enough for the purpose and the change in screen voltage is relatively small. This Note describes a method of conversion that produces a plate family whose useful range is not decreased by the conversion. The accuracy of the converted family, even for large changes in screen voltage, is high enough for most applications.

Principle of Method

The potential distribution within a tetrode or pentode of given physical structure depends on the voltages applied to the various electrodes. Multiplying all the electrode voltages by the same factor will not change the relative distribution of electrode potentials within the tube. Because the electrode currents in tetrodes and pentodes depend on the potential distribution between cathode and plate, the ratio of the several electrode currents to each other does not change when all the

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electrode voltages are multiplied by the same factor, provided space-charge effects change in proportion to the change in voltage. For example, a given family of plate characteristics obtains for a screen voltage (E_{c2}) of 250 volts; the per cent change in plate current for a change in bias is the same for a screen voltage of 300 volts if the plate-voltage scale and grid-bias parameters are multiplied by 300/250 = 1.2. The effects of contact potential are not considerd in this Note; however, they become serious only for small control-grid bias voltages.

Fig. 2 is the plate family of a 6L6 for a screen voltage of 250 volts. At any plate voltage, the ratio of the plate current (I_b) at a given control-grid bias to the plate current at zero bias does not change when the screen voltage is changed, provided the plate-voltage scale and grid-bias parameters are multiplied by the factor E_{c2}(new)/250 and operation is confined to regions in which space charge does not control the plate current. In order to convert a given plate family to a new screen-voltage condition, therefore, it is only necessary to have a zero-bias plate characteristic for the screen voltage of interest. A family of such characteristics for the 6L6 is shown in Fig. 1.

Example of Conversion

Suppose that the family of plate characteristics shown in Fig. 2, which obtains for a screen voltage of 250 volts, is to be converted for a screen voltage of 300 volts. The zero-bias plate characteristic for E_{c2} = 300 volts, which is shown in Fig. 1, is replotted, as at top in **Fig. 3.**

Since all bias values shown in Fig. 2 must be multiplied by 300/250 = 1.2, corresponding plate characteristics for the new family obtain for bias values that are 20 per cent higher than those shown in Fig. 2. Consider the conversion of the -10-volt characteristic of Fig. 2. At a plate voltage (E_b) of 250 volts in Fig. 2, AB/AC = 100/187 = 0.535. On the new characteristic in Fig. 3, which corresponds to a bias of -12 volts, A'B'/A'C' must also equal 0.535 at E_b = 300 volts. Therefore, A'B' = 0.535 x A'C'. From the given zero-bias characteristic of Fig. 3, A'C' = 244 at E_b = 300 volts; hence, A'B' = 131 milliamperes. At E_b = 200 volts in Fig. 2, DE/DF = 98/183 = 0.535. Therefore, at E_b = 200 x 1.2 = 240 volts in Fig. 3, D'E' = 0.535 x 238 = 127 milliamperes. This process is repeated for a number of plate voltages and a smooth curve is drawn through the points on the new characteristic.

The factor 0.535 can be used for the -10-volt characteristic at plate voltages greater than that at which the knee on the zero-bias characteristic of Fig. 2 occurs; for plate voltages in the immediate region of the knee, a new factor should be determined for each point. The plate characteristics of Fig. 2 should not be converted to the left of the dashed line of Fig. 2 because of space-charge effects. This limitation is not a serious one, however, because the region over which the tube usually operates can be converted with sufficient accuracy for most applications. The converted plate characteristic of Fig. 3 for E_{c1} = -30 volts was obtained in a similar manner to that for E_{c1} = -12 volts. The curves of Fig. 3 were checked under dynamic conditions by means of a cathode-ray tube. The dotted portions show regions where measured results departed from calculated results. Because the usual load line does not pass through regions in which plate current is affected by space charge, the calculated and measured curves yield nearly the same dynamic characteristics.

Determination of Approximate Operating Conditions

The curves of Fig. 2 are useful in estimating approximate operating conditions for various plate and screen voltages, control-grid biases, and load resistances. For single-tube operation, a load line should intersect the zero-bias plate characteristic in the vicinity of the knee; the plate current at which this intersection occurs should be approximately twice the d-c plate current. The load line should also pass through the no-signal plate-current point.

For example, a power supply is capable of furnishing 250 volts at approximately 40 milliamperes. What screen voltage, load, and bias are required for optimum output? The load should intersect a zero-bias characteristic near its knee at a plate current of approximately 75 milliamperes. From Fig. 1, this intersection occurs at a screen voltage of 150 volts and at a plate voltage of 40 volts, as shown. Therefore, the load resistance should be $(250-40)/(0.075-0.04) = 6000$ ohms. The power output is approximately $\frac{1}{2}(250-40)(0.075-0.04) = 3.6$ watts. The bias is easily determined by experiment or by converting the plate family to the new screen-voltage condition, from which low-order distortion components may be calculated. Some slight corrections will be necessary to account for rectification and for the assumed approximations. For push-pull Class A operation, the plate-to-plate load is twice that of a single tube; the power output is approximately twice that obtained from a single tube; the bias and the screen voltage are the same as those of a single tube.

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RCA-6L6

AVERAGE PLATE CHARACTERISTICS
WITH E_{C2} AS VARIABLE

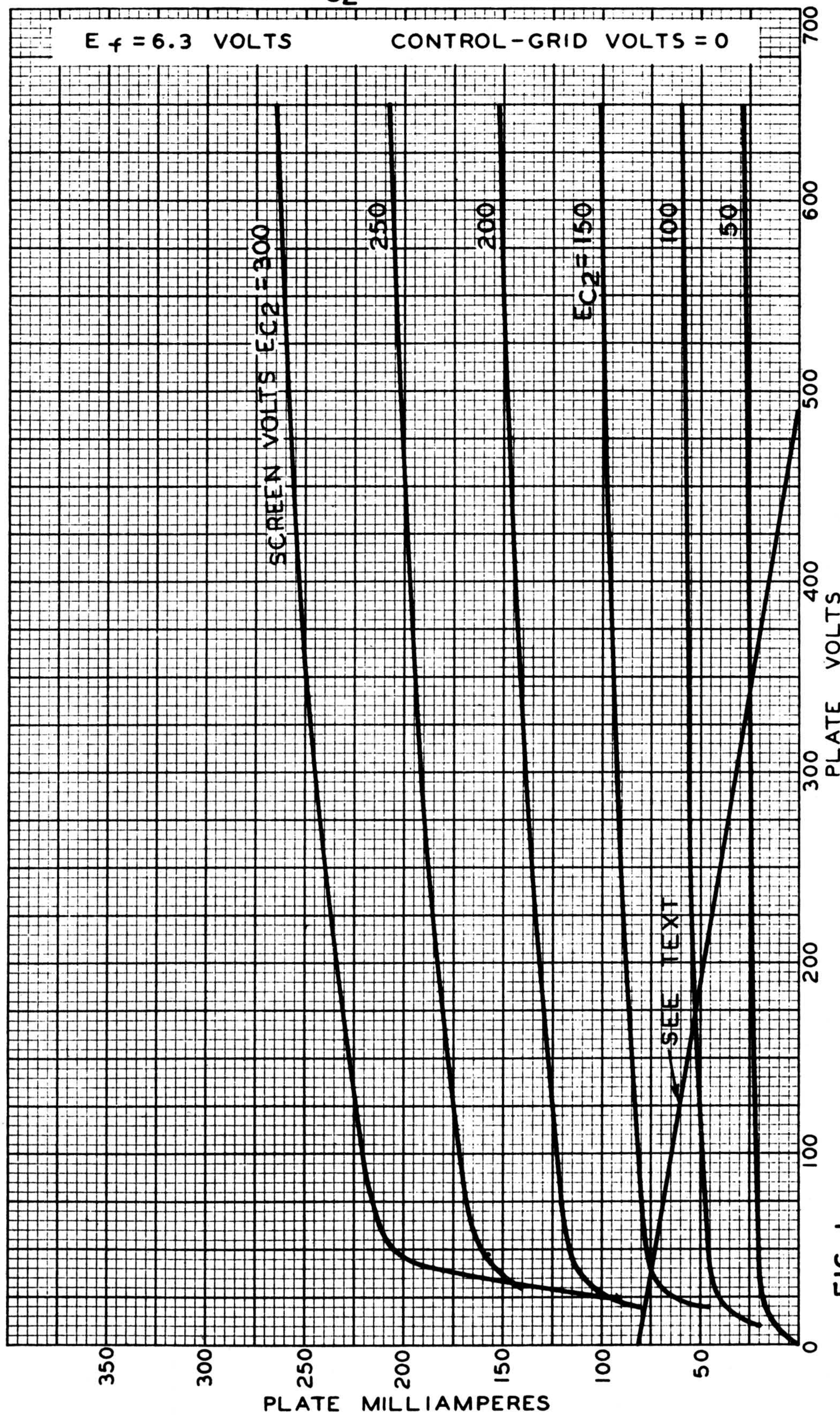

FIG. 1

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AVERAGE PLATE CHARACTERISTICS
WITH E_{C1} AS VARIABLE

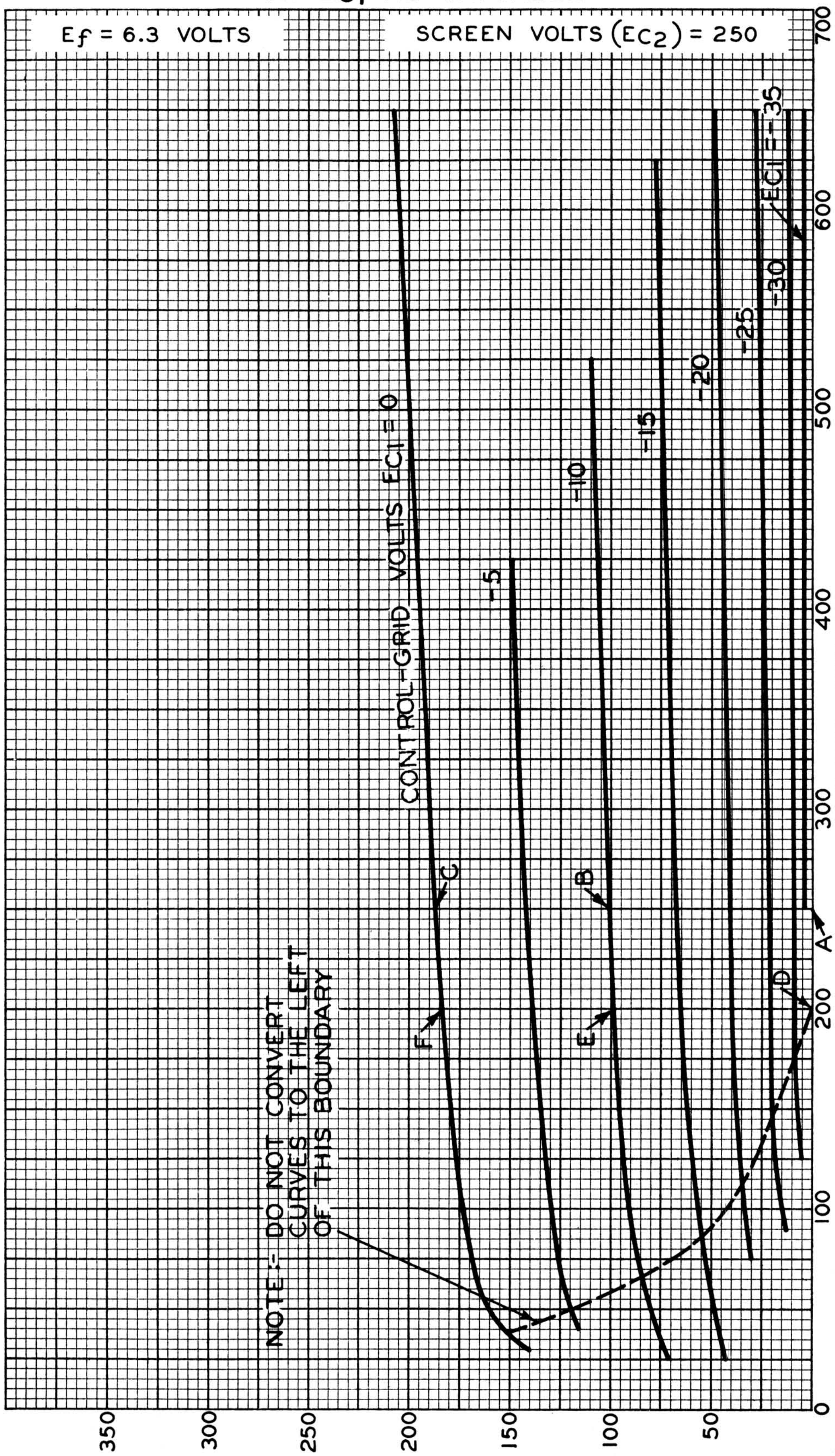

FIG. 2

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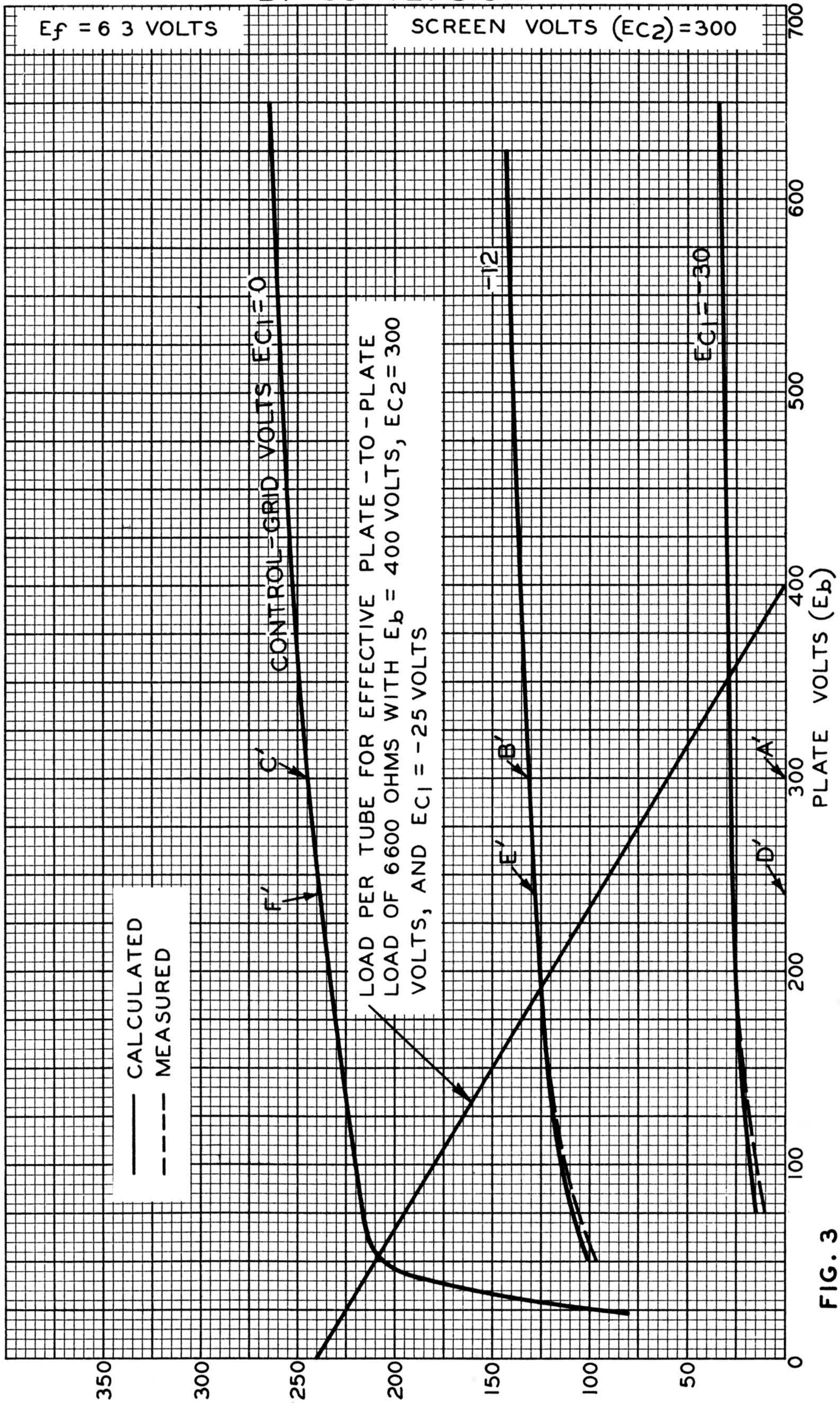
PLATE CHARACTERISTICS OBTAINED BY CONVERSION



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