

THEORETICAL AND PRACTICAL SCREEN GRID AMPLIFICATION

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Theoretically a modern screen grid tube will amplify about 400 times, but in practice the average amplification obtained is about 40 or less.

The purpose of this work was an attempt to obtain a greater practical amplification with the screen grid tube.

The amplification is defined as the ratio of the change of plate voltage to the change in grid voltage which produces the change in the plate voltage. This will be worked out from the plate current plate voltage or what is known as the plate characteristic curve Figure 1. The direct current resistance of the tube is E_p/I_p and the alternating current resistance is dE_p/dI_p . If the lines were straight and parallel the direct and alternating current resistance would be the same. Since the curves are neither straight nor parallel the plate resistance of the tube to the alternating current will be determined by the position on the curve at which the tube is worked.

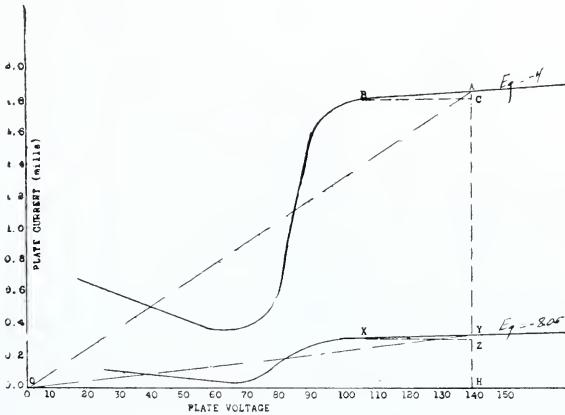


Fig. 1

There is no point on the upper curve at which the direct and alternating current resistance are the same unless the plate voltage is very high. At the point Y on the lower curve the alternating current resistance is of about the same magnitude as the direct current resistance. Therefore with a load resistance equal to the plate resistance of the tube the plate voltage supply of the tube would be only 300 volts in

order to have 150 volts on the plate. When the tube is operated with a high negative grid bias the two resistances of the tube are of the same magnitude, but too great a grid bias will make the plate current of the tube too low for it to operate.

If a resistance R is put in the plate circuit of the tube, the impedance of the plate circuit is $R + R_p$. The magnitude of the alternating current set up in the plate circuit due to the alternating grid voltage dE_g acting between the grid and the filament is given by $dI_p = u dE_g / (R + R_p)$ and this alternating current flowing through the resistance R gives an available voltage in the plate circuit of $R dI_p = u dE_g R / (R + R_p)$. By definition the above expression gives the voltage amplification. Thus the amplification constant of the circuit is $uR / (R + R_p)$. When $R = R_p$ an amplification of $\frac{1}{2}u$ is obtained for the circuit. If R was infinity the plate current would be zero, thus it is easily seen that as R increases the plate current decreases, therefore the value of R is limited.

In this work it was found that the tube worked best when the direct and alternating current resistances were the same and the load resistance was of about the same size.

The amplification of the tube was first measured by means of the circuit shown in Figure 2. The amplification constant of the tube measured in this way was approximately 380. Using this circuit the amplification is given by the expression $u = R'/R$.

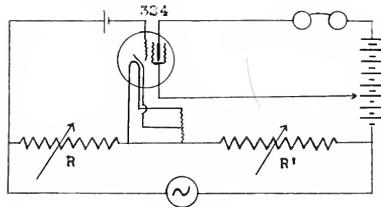


Fig. 2

Since the amplification has been defined as the ratio of dE_p to dE_g , but in this case dE_p bears the same relation to R' as does dE_g to R , because the grid voltage is determined by the voltage drop across R while the changing value of the plate voltage is determined by the voltage drop across R' . Then if adjustments are made such that a minimum sound is heard in the head set the amplification will be given by the equation $u = dE_p/dE_g = R'/R$.

The amplification was then measured by the use of a circuit such as shown in Figure 3.

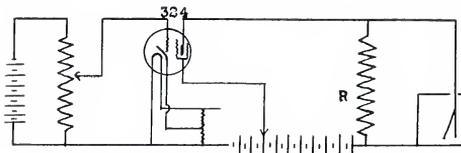


Fig. 3

This method was based upon the change of potential across R (by use of an electroscopie which had previously been calibrated) caused by a known change in the control grid potential. Using one megohm for R an amplification of 126 was obtained. Other values of R from .1 to 2 megohms gave smaller amplification factors.

The problem then arose as to the possibility of connecting the 324 to another tube without any great change in the amplification produced by the 324 tube. For this four tubes were tried, a 201A, a 245, a 210, and a 247. The results from the first three tubes mentioned were unsatisfactory, but with the 247 fair results were obtained when coupled as shown in Figure 4 and Figure 5.

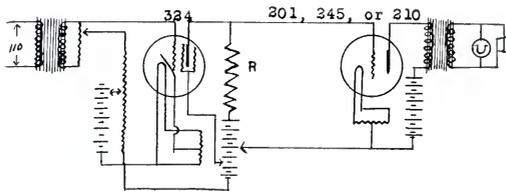


Fig. 4

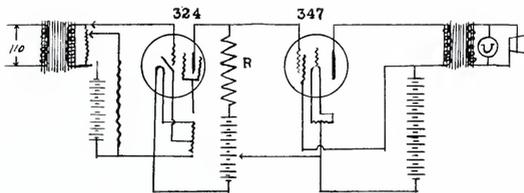


Fig. 5

When the tubes were coupled as shown in Figure 3 it was found that the greatest amplification was obtained with a load resistance of .5 megohm and enough control grid bias such that the plate current was approximately .4 milliamperes. The 224 was also coupled to the 347 by means of a transformer, but the results were not very satisfactory, at least not high enough to warrant its use. Impedance coupling also gave poor results.

From the results taken, allowing that the 347 amplifies 90 times, then the 324 has as amplification factor of 130 as a maximum value. Whereas Dowling¹ obtained an amplification of 150 by using the tube with a plate voltage of from 30 to 60 volts.

Figure 5 is a graph showing the variation of the amplification factor due to different control grid potentials for a constant input signal potential.

The output of a phonograph was used as the input during part of this work. The output in watts when the output transformer was connected to a dynamic speaker and a constant frequency record was used as the input the output was about 1.6 watts. Using an ordinary phonograph record for the input the output was about 1.2 watts which

is sufficient to operate three or four dynamic speakers as ordinarily operated for home use.

After obtaining the proper adjustments this circuit works very satisfactorily as a phonograph amplifier or as an audio amplifier, but care must be taken in the coupling of the input in order to prevent the circuit from acting as an oscillator.

It was noted that a very slight change in the plate current from .4 milliamperes was sufficient to cause the 324 to cease functioning as an amplifier.

For experimental purposes this circuit would be very satisfactory for amplifying small signals, but for commercial purposes it is not so well adapted as it is very critical in its adjustments and seems to change with the atmospheric changes. For a large input such that the control grid of the 324 tube left the peak of the grid bias amplification curve the amplification suddenly drops to one-half of its maximum value. Therefore for large input signals unequal amplification would be obtained.

For relatively small variations in the input voltage the variation in the amplification is not noticeable. An examination of the curve shows that over a very narrow range of grid voltage the amplification can be considered as a constant.

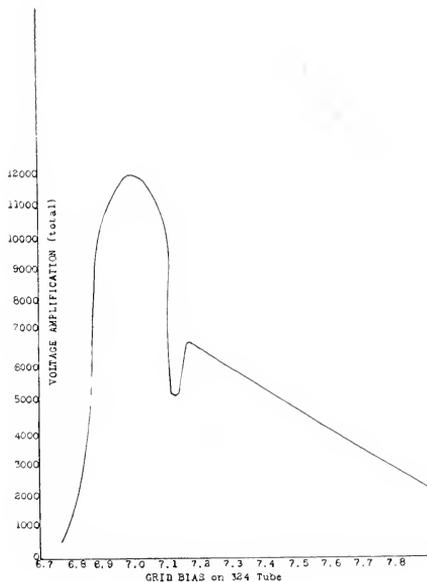


Fig. 6.

BIBLIOGRAPHY

Experimental Wireless & Wireless Engineer, February, 1928. p. 61.