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強力振盪器柵漏電阻的最佳調變方法

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本文敍述一種簡單的實驗指示方法，用以測定強力振盪器的最佳柵漏電阻。關於激發比率對板極效率的關係，和 Colpitts 線路中柵漏電阻的適當接法等問題，本文亦曾加以討論。

作實驗用的眞空管係 Sylvania 211 强力管。强力振盪器則採常用的 Hartley 和 Colpitts 線路。所用的直流板極電壓爲 1000 伏特，頻率爲一百萬週。曾用適當的相角補償法，使振盪器得到較良好的工作路。綜合實驗結果，可得下列四點：

（一） 在每一種負載情形下，都可以找到一個最佳的柵漏電阻，使得振盪器的板極效率最高，功率輸出也最大。這個最佳柵漏電阻之值，可以由等值線圖上預先求得。計算值和實驗結果相比較，如第一表所示。因理想的直線工作路不易得到，故準確度不能太高。

（二） 槽蘊電路（tank circuit）中的熱偶安培計，可以作爲最佳柵漏電阻的指示器。當柵漏電阻由極大之值逐漸減少時，槽蘊電流隨之逐漸增加，至某一點當槽蘊電流開始停止增加時，此時的柵漏電阻卽爲最佳柵漏電阻（圖 2）。這種現象可以由等值線圖得到解釋。

（三） 由實驗結果顯示，當槽蘊電路中的負載不變時，如所用者爲最佳柵漏電阻，則激發比率增加時，板極效率也隨之增加。

（四） 如將 Colpitts 振盪器中的柵漏電阻 R_c，一端接於陰極，另一端接於槽蘊線圈中的某一點，使槽蘊電路形成平衡的射頻電橋時，則柵漏電阻的加載效應（loading effect）可以免除，板極效率因而提高（圖 4）。此射電頻率的中性點，可用簡單的實驗方法求得。

本文所述問題，係由馮秉銓博士提出，幷得其指導不少，特此誌謝。

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ON THE OPTIMUM ADJUSTMENT OF GRID LEAK RESISTANCE OF A POWER OSCILLATOR

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ABSTRACT

This paper presents an experimental method to determine the optimum grid leak resistance of a power oscillator. The effect of excitation ratio on the plate efficiency and the proper method of connection of the grid leak resistance are also discussed. The experimental results are checked against the calculated values obtained from graphical method.

1. INTRODUCTION

It has been pointed out in a previous paper[1] that for a given excitation ratio and load resistance, there seems to be an optimum value of grid leak resistance to be used with a power oscillator tube. In the accompanying article[2], we pointed out that along a constant load resistance contour, there is a point tangential to a constant plate efficiency contour. This point gives the highest plate efficiency for a given value of load resistance. The graphical method, although useful and convenient, is rather laborious. This paper describes a simple experimental method by which the optimum grid leak resistance can be determined directly. The experimental results were found to check very well with the results obtained by the graphical method.

2. EXPERIMENTAL RESULTS

A Sylvania 211 tube is used in a shunt-feed Hartley and Colpitts oscillator circuits with a plate supply voltage of 1000 volts and operating at a frequency of 1 mc. The load resistance of the oscillator is varied from 2500 to 9900 ohms by adjusting a calibrated non-inductive resistance R_T placed in series

1. P. C. Feng, "Notes on the Plate Efficiency of Power Oscillators" *Chinese J. Phys.* **7** (1949), 249-257.
2. P. C. Feng & P. C. Hsu, "Graphical Predetermination of the Performance of Power Oscillators," the preceeding paper.

with the tank circuit. The excitation ratio is varied from 0.2 to 0.5 by adjusting the position of the filament center-tap on the tank coil or the tank condenser. To insure good paths of operation, suitable plate and grid blocking capacitors are used and adjusted until a desirable path is obtained. The path of operation is directly observed on the screen of a cathode ray oscilloscope with the aid of properly designed voltage dividers. Fig. 1 shows the circuit of the oscillator with its circuit constants indicated. The experimental results can be summarized as the following.

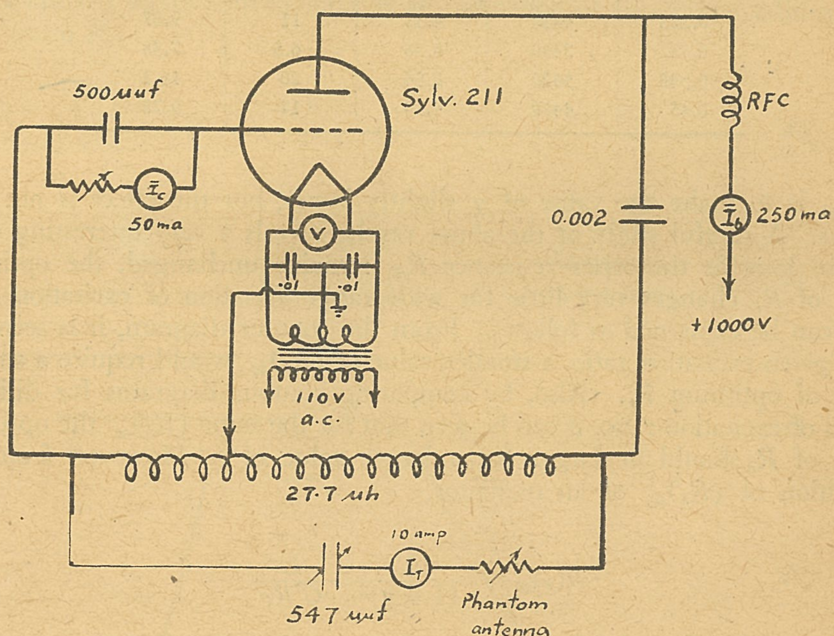

Fig. 1

(1) *Optimum Grid Leak Resistance*

For each load condition, there is an optimum value of grid leak resistance which can be pre-determined from the contour diagrams calculated from the static characteristics. These optimum values of R_c are directly found by experiment and the results were found to agree with the calculated results within a difference of 10% in most cases. This is considered to be fair in view of the difficulty of obtaining a true straight line path of operation. In general, for a given excitation ratio, the optimum value of R_c decreases with decreasing load resistance $(R_b)_\omega$. The following table shows some of the results obtained.

In general, the excitation ratio is slightly changed when the load is varied although the position of the coil tap remains the same. The effect of reducing

TABLE 1

χ	$(R_b)_\omega$ (Ω)	R_T (Ω)	Optimum R_c (kΩ)	
			calculated	experimental
0.202	9900	2.54	16	16.1
0.186	6560	4.33	10	9.07
0.191	4180	6.36	5.5	7.51
0.366	7320	2.54	17	16.1
0.358	4650	4.33	11	9.07
0.337	2490	6.36	6.5	7.58
0.548	5620	2.54	20	16.1
0.45	4470	4.33	12	9.78

$(R_b)_\omega$ is to make the value of χ slightly lower, but the effect is not very serious. A careful study of the above results reveals a very interesting effect that so long as the series resistance R_T remains unchanged, the optimum value of R_c changes very little for wide range variation of excitation ratio. This can be explained as follows. From the contour diagram, it is seen that for a given excitation ratio, a smaller value of $(R_b)_\omega$ would require a smaller value of optimum R_c. Also, by comparing contour diagrams for different values of excitation ratio, it can be seen that for the same $(R_b)_\omega$ the optimum value of R_c should be larger for a larger value of χ. However, from the definition of $(R_b)_\omega$ of an oscillator,

$$R(_b)_\omega = \frac{1}{(1+\chi)^2}\,\frac{L}{C R_T}$$

we see that for constant values of L, C, and R_T, an increase of excitation ratio would always result in a decrease in $(R_b)_\omega$. Thus the independent effects on the value of optimum R_c of the changes of χ and $(R_b)_\omega$ tend to nullify one another with the result that the optimum value of R_c tends to remain constant for wide range variation in excitation ratio.

(2) *Experimental Indication for Optimum Adjustment*

For a given excitation ratio and load resistance, the power output, input, and plate efficiency will vary as R_c is adjusted. Fig. 2 shows a plot of the measured plate efficiency and the R. F. tank current versus the grid leak resistance. This is just one of the typical examples among a large number of sets of data we obtained. When R_c is decreased from a very large value, the tank current at first rises very fast. At a point where the tank current ceases to increase and begins to remain constant, the observed efficiency is found to be maximum. This fact can be explained easily by the contour diagrams described in the accompanying paper. When R_c is decreased, we are following a constant $(R_b)_\omega$ contour. An examination of the shapes of the load resistance, plate efficiency, and power output contours shows that at a point where the load resistance contour is tangential to one of the plate efficiency contours, the efficiency is a maximum. It can also be seen that it is also at this point that the load resistance contour becomes practically tangential and continues to be tangential to the power output contour. Since a maximum tank current indicates a maximum power output, the sudden cease of increase in tank current serves conveniently as an indication of the correct adjustment of optimum R_c.

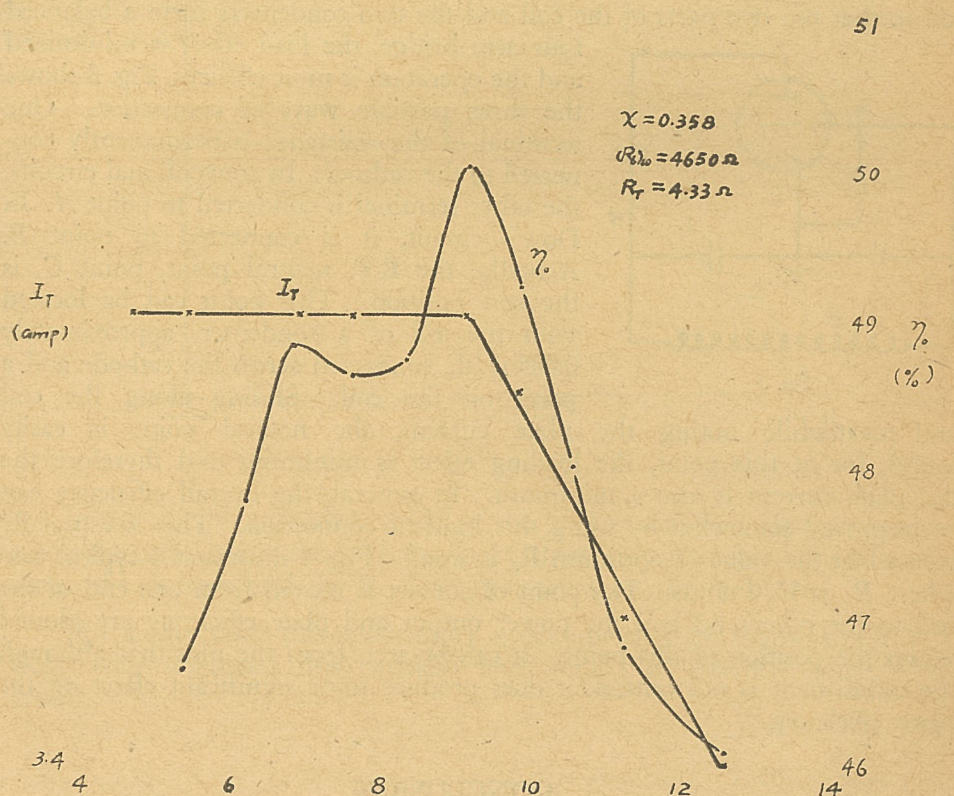

Fig. 2

(3) *Effect of Excitation Ratio on Plate Efficiency*

Within the normal operating range of the excitation ratio (0.2 to 0.5), it was found that the larger is the excitation ratio, the higher will be the plate efficiency so long as the value of R_c is adjusted to its optimum value. The only limitation is that when the excitation ratio is too high, the grid dissipation may exceed the rated value of the tube.

(4) *Proper Connection of the Grid Leak Resistance*

Ordinarily, the grid leak resistance is connected across the grid and cathode or filament center tap of the tube. It is suggested[3] that sometimes it is better to connect it across the cathode and the plate terminal of the tank coil in the case of a Colpitts oscillator circuit. The purpose of doing this is to reduce the load effect in order to improve the frequency stability. This will, however, reduce the overall efficiency of the power oscillator. By connecting the grid leak resistance between the cathode and a point on the coil so that the two parts of the coil and the two condensers form a balanced four arm bridge, the load effect is minimized and the operation is most efficient. Fig. 3 shows the three possible ways of connection. One terminal of the resistance is permanently connected to the cathode. In conventional circuits, the other terminal is connected to point *A*. In Dow's circuit, it is connected to point *B*. Actually, the R.F. neutral point, point *C*, is the best position. This point can be located with the aid of a condenser, approximately 0.005 μ fd., connected across the cathode and a point on the coil. Sliding along the coil and meanwhile noting the plate current, the neutral point is easily found, for at this point, the loading effect is minimum and therefore the d.c. plate current is also a minimum. In general, the overall efficiency can be improved somewhat by using this kind of connection. This is especially true when the value of optimum R_c is small. Fig. 4 illustrates a typical case where R_c is 5570 ohms. The point of contact is moved from one end of the coil to the other end and the power output and plate efficiency are plotted versus the position of this point. It can be seen from the plot that although the adjustment is not critical, it does produce some significant effect on the plate efficiency.

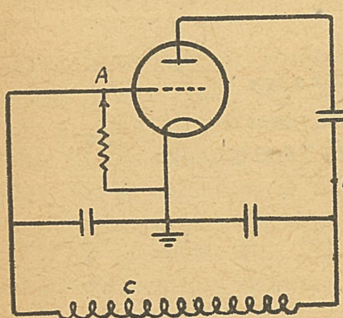

Fig. 3

3. CONCLUSION

The general belief[4] that the grid bias of a power oscillator should be equal to 1.5 times the cut-off value is found to be not always true. Instead, there

3. J. B. Dow, "A Recent Development in Vacuum Tube Oscillator Circuits" *I.R.E. Proc.* **19** (1931), 2095.
4. For example, R. I. Sarbacher, *Hyper and Ultra-high Frequency Engineering*, (John Wiley & Sons, 1st Edition), p. 507.

is definitely an optimum value of grid leak resistance. This value can be found either by the comparatively laborious graphical method or the simple experimental method here described. The tank current meter serves as a very convenient indicator for this adjustment.

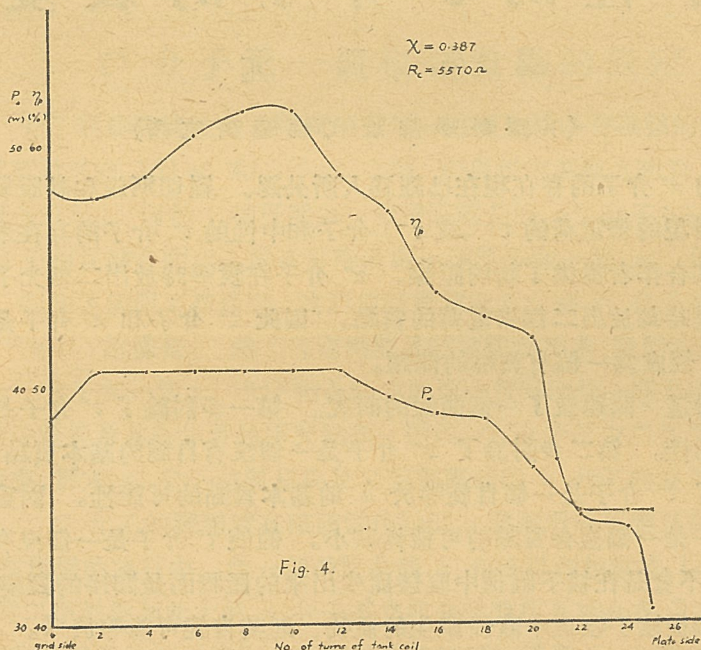

Fig. 4

In the case of a Hartley oscillator, the grid resistance is always connected across the cathode and the grid; but in a Colpitts circuit, it should be connected across the cathode and the R. F. neutral point on the tank coil.

The author takes this opportunity to acknowledge his thanks to Dr. P. C. Feng who suggested this problem and helped to interpret some of the results.