RCA MANUFACTURING COMPANY, INC.

A RADIO CORPORATION OF AMERICA SUBSIDIARY

Harrison, New Jersey

RCA RADIOTRON
DIVISION

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APPLICATION NOTE ON OPERATION OF THE 6A8

Optimum performance of a superheterodyne receiver cannot be realized unless the mixer-oscillator section satisfies certain requirements. Unfortunately, however, these requirements usually conflict with other conditions for optimum performance. In practice, therefore, it is necessary to effect a suitable compromise. For example, the oscillator voltage of the 6A8 must be greater than a certain minimum value for reasonable mixer-stage gain. It has been found that this requirement immediately limits the frequency range which can be covered in a single band. Hence, a compromise between frequency coverage and mixer-stage gain must be reached. It is the purpose of this Note to discuss some of the problems associated with the design of pentagrid-converter circuits and to present data on the operation of the 6A8, the all-metal pentagrid-converter tube.

A pentagrid converter produces an i-f component of plate current because of modulation in the electron stream of an r-f signal by an oscillator voltage applied to the No.1 grid. The magnitude of the i-f component of plate current is equal to the product of the conversion conductance (g_c) of the tube and the r-f signal voltage when the load impedance is small compared to the internal resistance of the tube. Since the conversion conductance is a function of the oscillator voltage, the i-f component of plate current, and hence the mixer-stage gain, is dependent on the magnitude of the oscillator voltage.

Measurement of the oscillator voltage applied between oscillator grid and cathode of a mixer tube is often inconvenient and is sometimes subject to appreciable error. For these reasons, it is desirable to use the d-c oscillator-grid current as a measure of the oscillator voltage. For all practical purposes, therefore, a curve showing the relation between conversion conductance and d-c oscillator-grid current through a given resistance can be used to predict mixer-stage performance. This grid current may be measured by connecting a d-c milliammeter of proper range between the cathode and the low-potential terminal of the oscillator-grid resistance.

Effects of High Oscillator-Grid Currents

In the usual type of oscillator circuit, the oscillator voltage nearly always increases with frequency throughout any wave range of an all-wave receiver; this increase is due to the increasing impedance of the tuned circuit and to the increasing plate-grid feedback as the receiver is tuned to the high-frequency end of the band. Thus, if the oscillator-grid current is made high at the low-frequency end of a range, good mixer-stage gain throughout that band might be expected. However, experience has shown that the frequency range of the band may be seriously limited if the size of the tickler is increased in order to obtain high oscillator-grid current at the low-frequency end.

It has been found that the upper frequency limit of the range can be determined by the resonance frequency of the tickler coil and its associated shunt capacitance; this resonance frequency may lie within the theoretical tuning range of the band. When such a condition exists, the tickler determines the frequency of oscillation; this frequency remains fixed for any higher-frequency setting of the tuning condenser. Experience has shown that it is possible to obtain a tuning ratio of slightly more than 3 to 1 when the highest-frequency band tunes to approximately 18 megacycles and when the grid current throughout this frequency range is sufficient to insure good mixer-stage gain. In general, for frequencies higher than 18 megacycles this tuning ratio decreases, because the inductance of the tickler and the magnitude of the shunt capacitance do not change rapidly. A maximum oscillator-grid current for each operating condition is recommended. Currents in excess of these recommended values may seriously curtail the effective tuning ratio.

Another reason for limiting the size of the tickler is to prevent the oscillator from relaxing periodically. It has been found that, for the given values of oscillator-grid resistance and capacitance, relaxation effects may occur when the oscillator-grid current exceeds the maximum value recommended.

Oscillator-Grid Current Requirements

Curves of conversion conductance and cathode current (I_k) vs. oscillator-grid current through 50,000 ohm (I_{c1}) for the 6A8 are shown in Figs. 1 to 4; these curves correspond to the four operating conditions normally encountered in practice. Consider Fig. 1, which pertains to 250-volt, fixed-bias operation. As the oscillator-grid current decreases, the cathode current rises; I_k eventually exceeds the rated maximum current of 14 ma. The high cathode current at small oscillator-grid currents is a result of the small negative bias on the oscillator-grid at low oscillator voltages.

The conversion conductance of the 6A8 varies with I_{c1}. The curve approaches flatness over a large range of oscillator-grid currents, but drops quite rapidly for small values of I_{c1}. Thus, when I_{c1} = 120 microamperes (0.12 milliampere), the cathode current is 14 milliamperes, the maximum rated value, and the conversion conductance is 350 micromhos.

It is evident from Fig. 1 that I_{c1} should not be less than 120 microamperes for the operating conditions specified in the figure. Oscillator-grid currents less than this minimum value will result in decreased tube life and low mixer-stage gain. The maximum oscillator-grid current recommended for this condition is 500 microamperes. Experience has shown that this current can be obtained without any of the undesirable effects mentioned previously.

Curves of g_c and I_k vs. I_{c1} through 50,000 ohms for 250-volt, self-bias operation are shown in Fig. 2. In this case, the minimum value of oscillator-grid current (90 microamperes) is also determined by the rated maximum cathode current. This minimum is lower than that for fixed-bias operation, because of the effect of the self-biasing resistor in limiting the cathode current. The recommended maximum value of I_{c1} is 500 microamperes. These recommended minimum and maximum oscillator-grid currents can be obtained when the tuning ratio is approximately 3 to 1 and when the highest-frequency range tunes to about 18 megacycles. As with fixed-bias operation, the tuning ratio is reduced as the upper operating frequency is increased. Thus, the same considerations regarding tickler-coil design obtain for self- as for fixed-bias operation.

Figs. 3 and 4 show the recommended minimum and maximum oscillator-grid currents through 50,000 ohms for 100-volt operation with both fixed- and self-bias conditions.

Receiver Testing in Production

When the i-f amplifier of receivers which use the pentagrid converter is aligned, the oscillator section of the tube should be in operation. During this test, it is common practice to apply a signal of intermediate frequency to the signal grid of the pentagrid converter and then adjust the i-f circuits for maximum gain. If the oscillator is not operating, the bias of the oscillator-grid is zero; consequently, the gain of the mixer stage as an amplifier is higher than that which can be obtained when the oscillator is operating. The i-f gains obtained with and without the oscillator in operation may lead to erroneous conclusions.

As pointed out previously, the gain of the mixer stage is a function of the oscillator-grid current. Therefore, when aligning the i-f circuits with the oscillator in operation, it is important that the settings of the gang condenser and the oscillator padding condensers should be approximately the same in all receivers. By observing this precaution, the tester is able to compare the i-f gain of any receiver with some standard under similar operating conditions.

It should be emphasized that there may be no definite relation between the gain of the 6A8 when it is operated as an amplifier and when it is operated as a converter. The gain of the 6A8 when it is used as a converter should be compared to a standard which is also used as a converter.

Blocking of the Receiver when Tuned to a Strong High-Frequency Signal

Some receivers seem to block, or motor-boat, when tuned to a strong high-frequency signal. In a number of cases, this has been traced to poor regulation of the oscillator-anode and screen voltage sources. The voltages for these electrodes are usually obtained from the low-voltage side of a filter choke, which may have a resistance of 1000 ohms or more. Variations in current through this choke, caused by tuning the receiver to a strong signal, change the voltage applied to the oscillator-anode and screen. This change in voltage shifts the frequency of the oscillator voltage; this shift becomes important at high radio frequencies. Hence, the oscillator detunes periodically at an audio-frequency rate and consequently produces modulation of the carrier amplitude.

Fig. 5 is a circuit which minimizes this effect. The oscillator-anode and screen voltages are applied through the resistance-capacity filter (R C); C_1 is a mica high-frequency by-pass condenser and R_1 is a screen voltage-dropping resistor. The values of R and R_1 depend on the voltage input to the filter. Since the filtering action is dependent on the time constant of R and C, not more than one tube (the pentagrid converter) should be supplied by this filter, as the value of R is inversely proportional to the current through it. In general, this circuit is not necessary on 100-volt operation, because the filter choke usually has a sufficiently low resistance to provide good regulation.

SUMMARY TABLE

TYPICAL OPERATION OF THE 6A8

	100-VOLT CONDITIONS FOR			250-VOLT CONDITIONS FOR			
	Recommended MAXIMUM Osc.-Grid Cur.	Recommended MINIMUM Osc.-Grid Cur.		Recommended MAXIMUM Osc.-Grid Cur.	Recommended MINIMUM Osc.-Grid Cur.		
	Fixed- or Self-Bias *(Figs. 3 & 4)*	Fixed-Bias *(Fig. 3)*	Self-Bias *(Fig. 4)*	Fixed- or Self-Bias *(Figs. 1 & 2)*	Fixed-Bias *(Fig. 1)*	Self-Bias *(Fig. 2)*	
Plate Voltage	100	100	100	250	250	250	Volts
Screen Voltage	50	50	50	100 max.	100 max.	100 max.	Volts
Anode-Grid Voltage	100	100	100	250 #	250 #	250 #	Volts
Control-Grid Voltage *	-1.5 min.	-1.5 min.	-1.5 min.	-3 min.	-3 min.	-3 min.	Volts
Oscillator-Grid Resistor	50000	50000	50000	50000	50000	50000	Ohms
Oscillator-Grid Condenser	50	50	50	50	50	50	μμf
Oscillator-Grid Current	0.25 max.	0.05 min.	0.05 min.	0.5 max.	0.12 min.	0.09 min.	Milliamperes
Plate Current	1.2	2.1	1.7	3.3	5.3	4.2	Milliamperes
Screen Current	1.5	2.1	2.0	3.2	4.3	4.7	Milliamperes
Anode-Grid Current	1.6	2.1	2.2	4.0	4.4	5.1	Milliamperes
Conversion Conductance	350	250	250	500	350	300	Micromhos
Grid Voltage (Approx.) for Conv. Cond. of 2 μmhos	-20	-20	-20	-45	-45	-45	Volts

* When self-bias is used, the self-bias resistor should have a value of 350 ohms for the 100-volt conditions, and 300 ohms for the 250-volt conditions.

This is an Anode-Grid Supply voltage applied through a 20000-ohm voltage-dropping resistor.

Note: Total Cathode Current = 14 Milliamperes Maximum.
Anode-Grid Voltage = 200 Volts Maximum.

RCA Cunningham Radiotron RADIO TUBES

RCA-6A8

OPERATION CHARACTERISTICS
WITH 50000-OHM OSCILLATOR-GRID LEAK

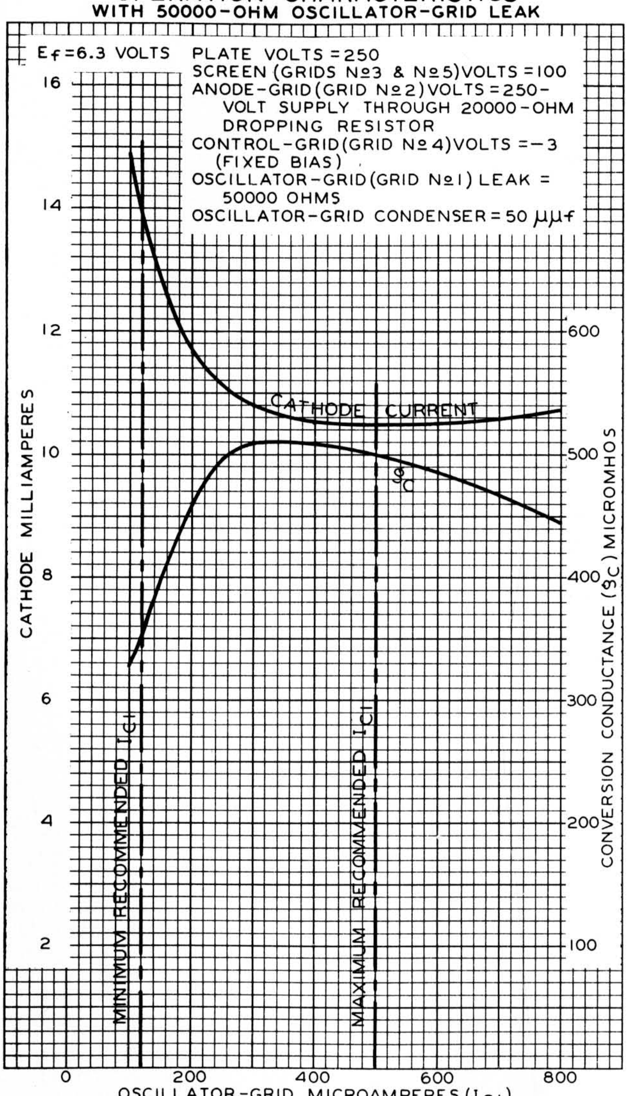

FIG.1

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RCA Cunningham Radiotron RADIO TUBES

RCA-6A8

OPERATION CHARACTERISTICS
WITH 50000-OHM OSCILLATOR-GRID LEAK

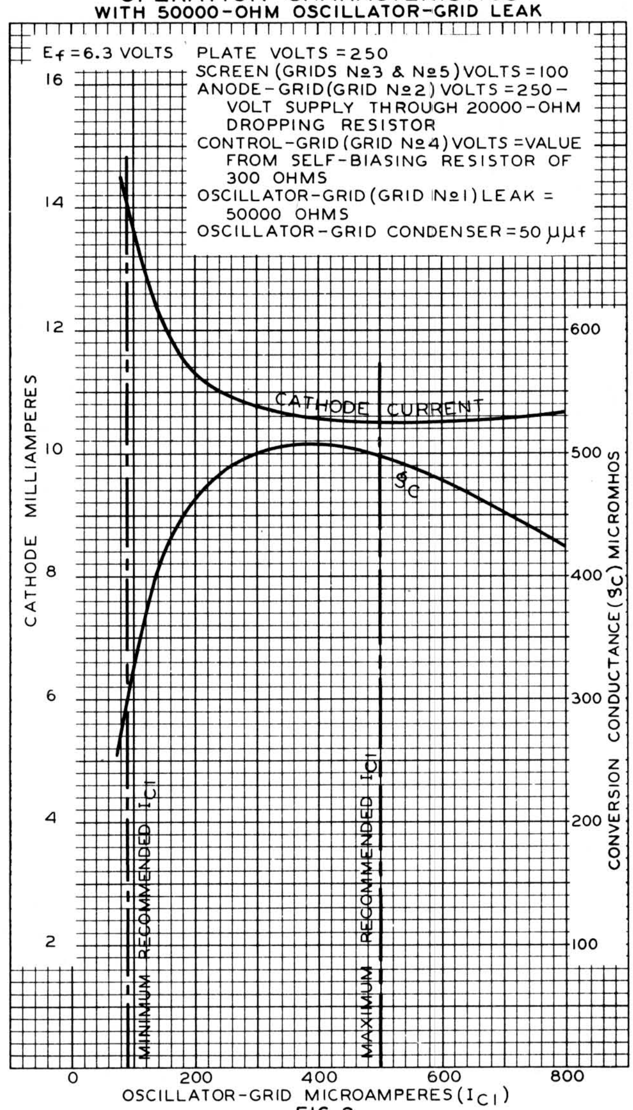

FIG.2

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RCA-6A8

OPERATION CHARACTERISTICS
WITH 50000-OHM OSCILLATOR-GRID LEAK

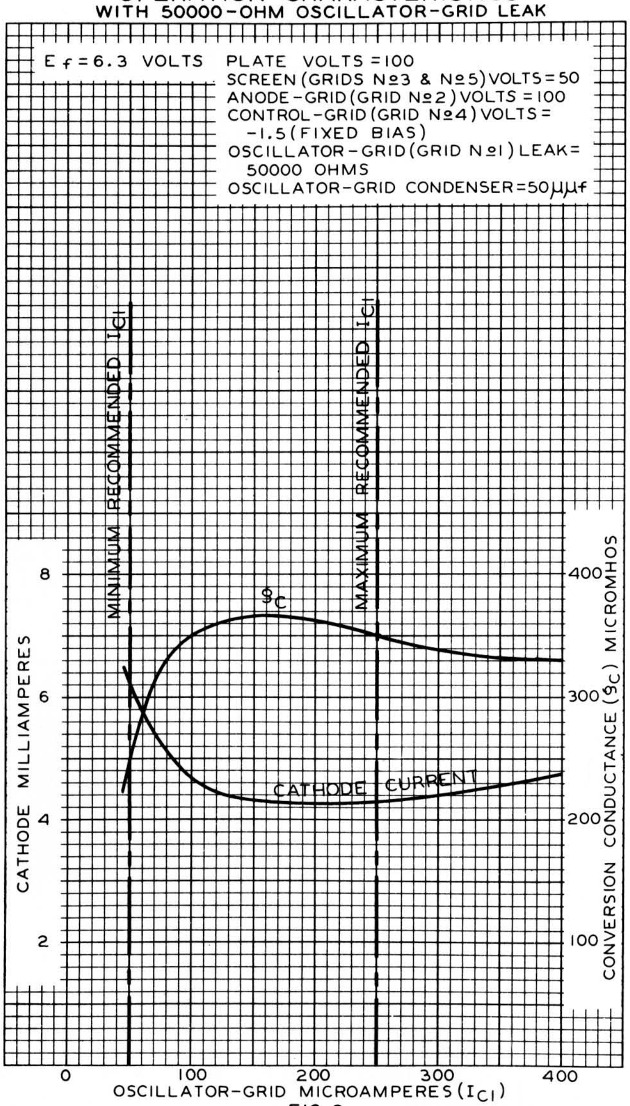

FIG. 3

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RCA-6A8

OPERATION CHARACTERISTICS
WITH 50000-OHM OSCILLATOR-GRID LEAK

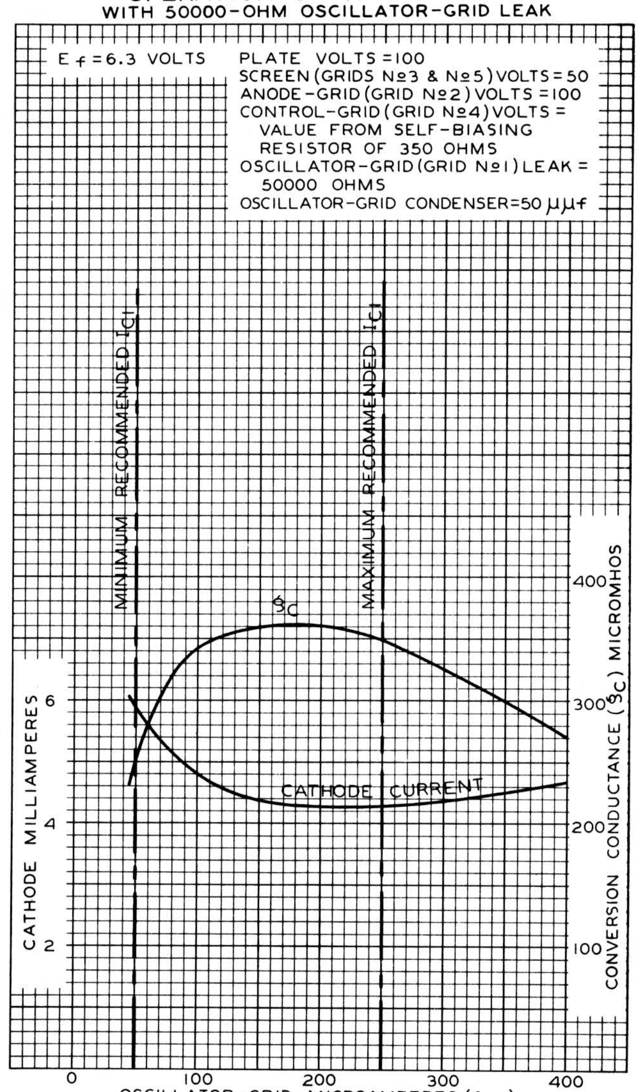

FIG. 4

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SCHEMATIC CIRCUIT FOR TYPE 6A8 WITH POWER-SUPPLY FILTER

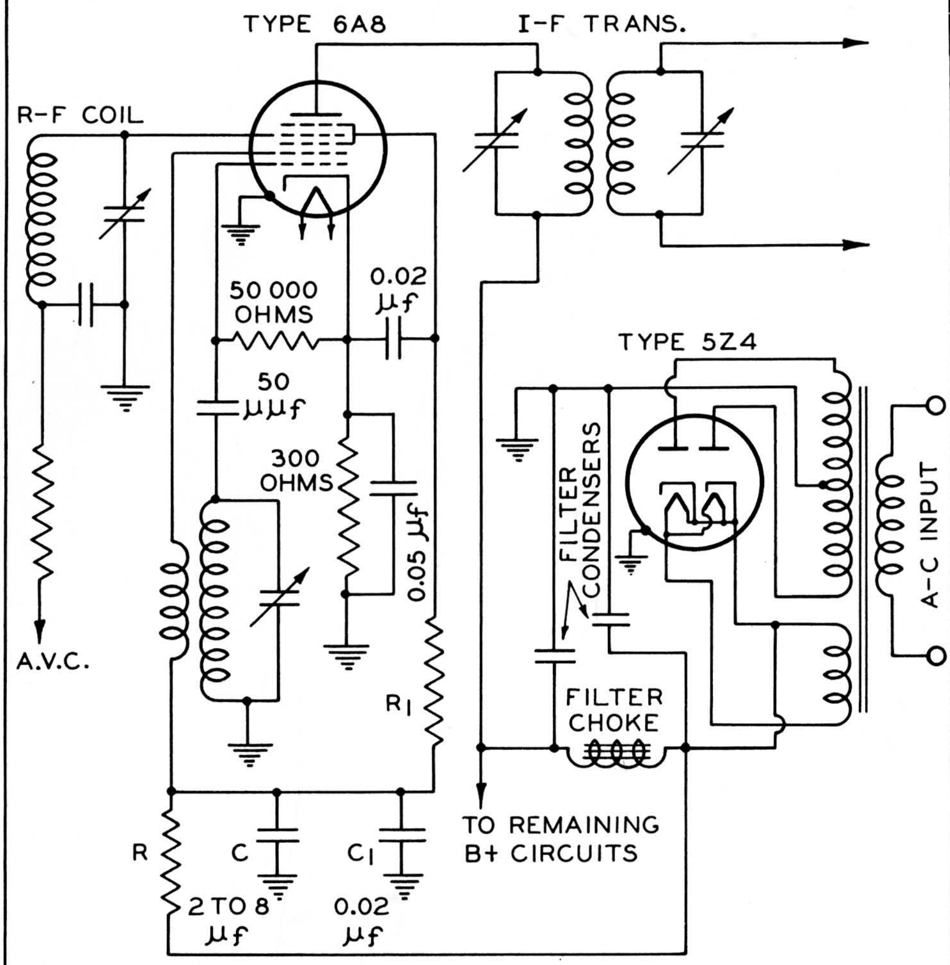

FIG. 5