



RCA MANUFACTURING COMPANY, INC.

A RADIO CORPORATION OF AMERICA SUBSIDIARY

Harrison, New Jersey

APPLICATION NOTE No. 111

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THE NEW HIGH-TRANSCONDUCTANCE R-F PENTODE RCA-6SG7

The 6SG7 is a medium cut-off r-f pentode having high transconductance, a very low grid-plate capacitance, and a 0.3-ampere heater. The high transconductance is obtained without excessive plate-current requirements or abnormal input and output capacitances. In addition, the high-frequency performance of the 6SG7 is enhanced, as will be explained later, by providing its cathode with two terminals. The 0.3-ampere heater permits the use of this tube in 0.3-ampere heater strings of a-c/d-c receivers. The features of this new pentode make it practical to improve the performance of high-gain i-f systems, of high-frequency r-f and i-f circuits such as are required for frequency-modulation and television reception, and of untuned r-f stages covering the range from 550 kilocycles to, say, 18 megacycles. These features will be explained in more detail in the following paragraphs.

Transconductance

All of the important uses for an improved r-f pentode call for high transconductance. The 6SG7 has a transconductance of 4000 to 4700 micromhos, depending on the value of the screen voltage. This high transconductance helps to counteract the losses incurred in circuits having low values of load impedance, such as are used in untuned amplifier stages, broad-band high-frequency i-f systems, and tuned high-frequency r-f stages where the circuit conditions are unfavorable to reasonably high gain.

Transconductance curves for various screen voltages as well as other characteristics curves for the 6SG7 are included at the end of this Note.

Capacitances

The grid-plate capacitance of the 6SG7 has a normal value of 0.002 μmf , and a maximum value of 0.003 μmf . This low value favors the stability of an amplifier stage when very high gain is to be realized by the use of efficient circuits and a tube having high transconductance. In high-gain stages, regenerative feed-back through the grid-plate capacitance is a limiting factor in circuit design.



The 6SG7, with its input capacitance of 8.5 $\mu\mu\text{f}$ and output capacitance of 7 $\mu\mu\text{f}$, may be substituted for other r-f pentodes in conventional circuits without requiring circuit capacitance or inductance adjustments beyond the usual capabilities of trimmers.

Cathode Connections

Two cathode terminals are provided for the 6SG7 in order that the plate and screen r-f circuits may be completed through a minimum of circuit inductance common to the grid circuit. When, therefore, the grid-circuit return is connected to one cathode terminal and the plate and screen returns are connected to the other cathode terminal, the inductance common to the return circuits becomes only that of the cathode itself. As a consequence of this method of connecting the returns to the cathode, the input and output circuits can be effectively isolated from one another.

This arrangement has been provided in the 6SG7 because some of the important circuit problems encountered at high frequencies are caused by the loading effect of the input impedance of the tube. Although this impedance is complex, its most objectionable part is mainly the result of plate and screen signal currents flowing through whatever portion of the cathode circuit has inductance common to the input and output circuits. Even though care be taken with circuit wiring, there remains with single-cathode-terminal tubes a certain amount of inductance in the cathode lead within the tube itself. Although this inductance is not objectionable when the frequency is only a few megacycles, the effect it produces is proportional to the square of the frequency; it becomes serious at frequencies of the order of 50 megacycles.

Suppressor Connection

In the 6SG7, the suppressor is connected internally to the shell, a practice consistent with the use of two cathode terminals. Were the suppressor to be connected internally to the cathode, capacitance between plate and suppressor would provide coupling between the output circuit and the input circuit. Moreover, connecting the suppressor to either cathode terminal would require designating which cathode terminal should be used for each circuit. Then, too, there is the important consideration that connecting the suppressor to the cathode would result in considerable increase of capacitance between the cathode and other electrodes. This increase would be objectionable, particularly if an r-f voltage were impressed directly in the cathode circuit, a condition which is encountered when a frequency converter is excited by the cathode-injection method.

Tube Noise Considerations

Current literature approaches the subject of tube noise from the advantageous standpoint of a "noise-equivalent resistance." The noise developed in and delivered by a tube may be considered as equivalent to the response to a noise voltage actually impressed on the grid of the tube by a resistor at room temperature. The value of this resistor is the "noise-equivalent resistance." It is designated as $R_{e,q}$. In circuit analysis and in some phases of design work, a knowledge of $R_{e,q}$ is desirable.

For the 6SG7 used at its rated voltages, the calculated values of R_{eq} fall between 3000 and 3700 ohms.

A comparison of the use of a 6SG7 with that of an r-f pentode having lower transconductance was made in a typical untuned r-f stage covering the range from 550 kilocycles to 18 megacycles. The signal was applied through a standard dummy antenna; the tuned grid circuit used was that of a conventional receiver. At low signal levels, the noise improvement obtained by using the 6SG7 was of the order of 1 db in the broadcast band, 5 db at 6 megacycles, and 3 db at 16 megacycles.

At much higher signal levels, resulting in noise which was as much as 30 db below the audio output of the receiver, the 6SG7 seemed to be at a disadvantage when it was compared with tubes having lower transconductance and a more remote cut-off. This observation was the result of applying the entire avc voltage of the receiver to the medium cut-off 6SG7. A proper use of avc voltage throughout the receiver would result in a noise improvement by the 6SG7 at all signal levels. However, the low-level signal case is the important test.

Use as a Frequency Converter

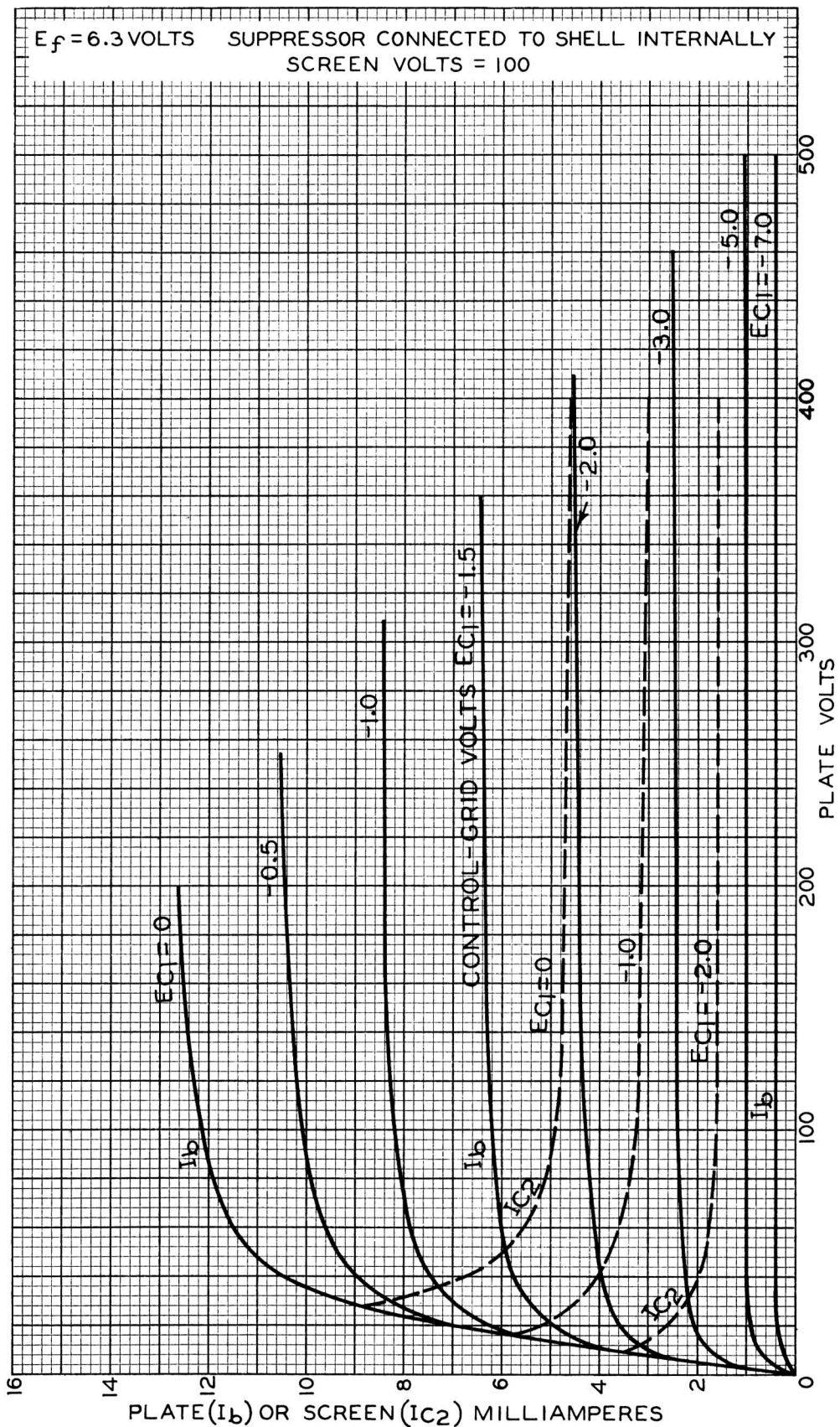
The 6SG7 may be used to advantage in a converter system as a pentode mixer when it is practical to provide suitable excitation. When an rms oscillator voltage of 3 to 5 volts can be developed between grid and cathode, a conversion transconductance of the order of 1500 micromhos can be obtained, and the noise-equivalent resistance as a mixer is of the order of 15,000 ohms.

When the operating frequency is low, or the tuning range not great, the oscillator voltage can be developed across the input circuit by capacitance or mutual inductance coupling; or the oscillator voltage can be introduced between the cathode of the 6SG7 and ground. When wide tuning ranges at high frequencies are involved (such as the 6 to 18 megacycle short-wave band), the wide range of variation of input-circuit impedance over the tuning range leads to serious difficulties with either injection method, and it is probably preferable in such cases to use the 6SG7 as an r-f stage followed by a pentagrid converter.



6SG7

AVERAGE PLATE CHARACTERISTICS



FEB. 13, 1941

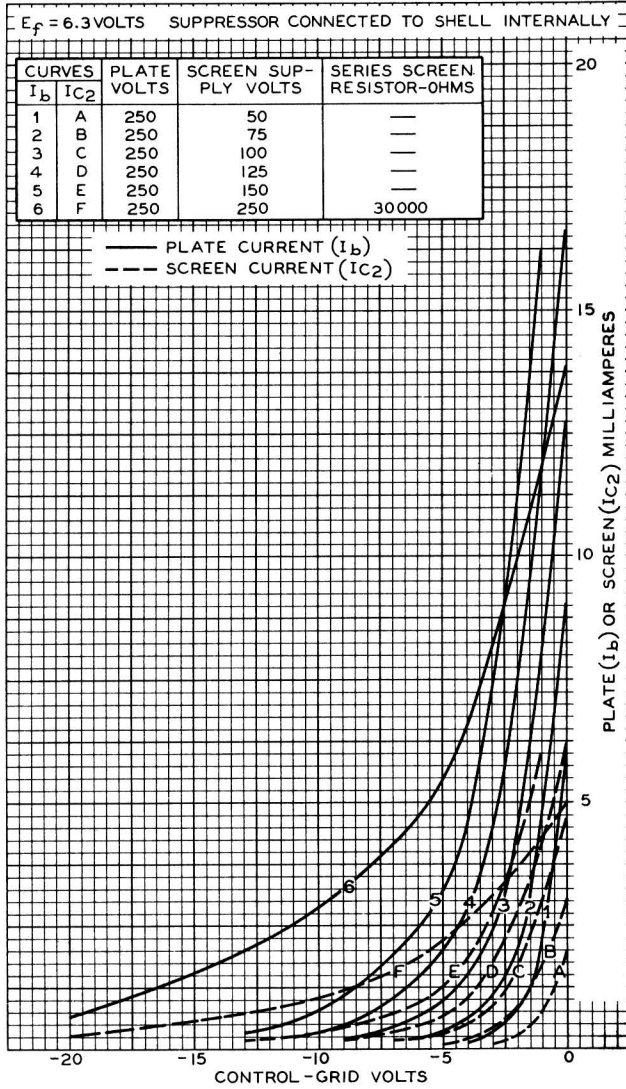
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6SG7

AVERAGE CHARACTERISTICS



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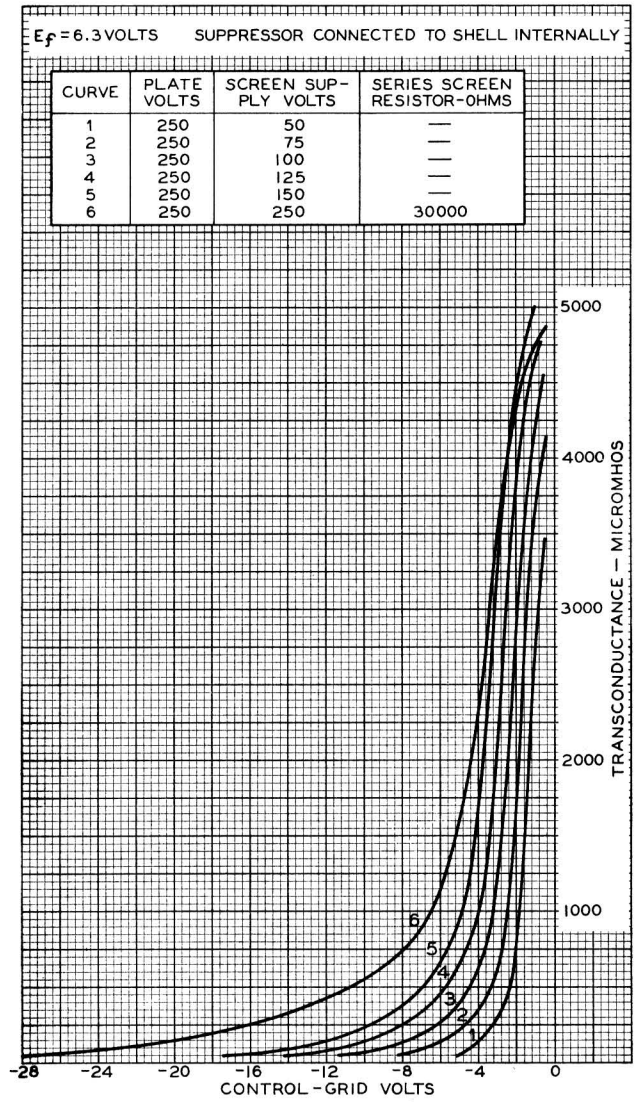
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6SG7

AVERAGE CHARACTERISTICS



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