TRIODE TUBE PARAMETERS
STATIC DC MEASUREMENTS

INDEPENDENT STUDY
SPRING 2000
UNIVERSITY OF ILLINOIS
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WITH
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INTRODUCTION

Electronic music is dependent upon the ability to amplify a signal. Amplifiers can contain either transistors or vacuum tubes as the active element. Various vacuum tubes are available that are usable in audio applications, all with different characteristics. This experiment tests the characteristics of 12A*7(dual) triode vacuum tubes. The characteristics of new manufacture and old tubes are compared with published values.

Vacuum tubes have three main components: a grid, a plate, and a cathode. A (dual) triode tube has two of each. The grid controls current through the tube. For a fixed plate voltage, any variation of grid voltage will cause the plate current to vary. With a very large resistance in series between the plate and the fixed power supply, the voltage drop across the resistor is much greater than the grid voltage and this is amplification of the voltage signal. However, the frequency of the output remains the same as the input.

It is safer to measure the voltage drop across the cathode, therefore in this experiment a 1ohm resistor is used in series with the cathode and no resistance is placed

between the plate and the power supply. This measured cathode current is equivalent to the plate current.

TEST SET-UP (FIGURE 1)

The grid voltage is controlled with a Digital-to-Analog Converter (DAC) using a PC programmed with C++ LabWindows/CVI DAQ program. A Digital-to-Analog Converter is a chip that converts a binary word into an analog signal. In this application, analog voltages between -5 and 1.255 are generated in increments of .01 volts. For each of these signals, a voltage measurement is taken off the cathode. This measurement is converted to a binary word representative of the measured voltage using an Analog-to-Digital Converter (ADC). Since the voltage drop is across a 1ohm resistor the reading is also representative of the current flow through the cathode, i.e. 1mV = 1mA. The plate voltages are adjusted by hand between each set of measurements.

TEST CIRCUIT (FIGURE 2)

The test circuit is assembled inside an aluminum box to reduce noise. The two plate pins and the two grid pins of the tube holder are tied so input to the two sets of plate and grid are identical. The heater pins are tied and

connected to a 6.3V_{ac} power supply. The power supply circuit is also enclosed in an aluminum box.

PROCEDURE

The order in which the three voltages are applied to the circuit is very important.

1. Place a tube in the tube holder. Be careful to place it in vertically and push. Do not rock or force the tube.
2. Plug in and turn on the heater power supply.
3. Start the computer program and place -5 volts on the grid.
4. Plug in and turn on the High Voltage power supply to 250 volts. *Do not turn on the high voltage power unless there is a voltage drop across the grid.*
5. Run the program for 250 volts and repeat for 200, 150, 100, and 50 volts.
6. Save the data as a .dat file to be opened in Excel for graphical analysis.

Data Run May 2000.

Three 12AX7(dual) triode tubes are tested. Groove Tube 7025_C is new stock manufactured recently. Two old stock, RCA_7025_6452, and RCA_7025_6435 are tested in relation to it. A family of curves is generated for each showing

cathode current in milliamps vs. grid voltage in volts. The most interesting tube was RCA_7025_6435 since the two sides of the tube had a much greater difference in output than the other two tubes tested. (Graph 1,2,3). This is shown in Graph 4,which compares the 250volt output of the three tubes.

Tom Mitchell in his manual *The Audio Designer's Tube Register* states that the tubes manufactured today are subtly different from the tubes made in the 1950's.[1] The difference is very subtle and at some grid voltages the old tube and the new tube have the same output of current.

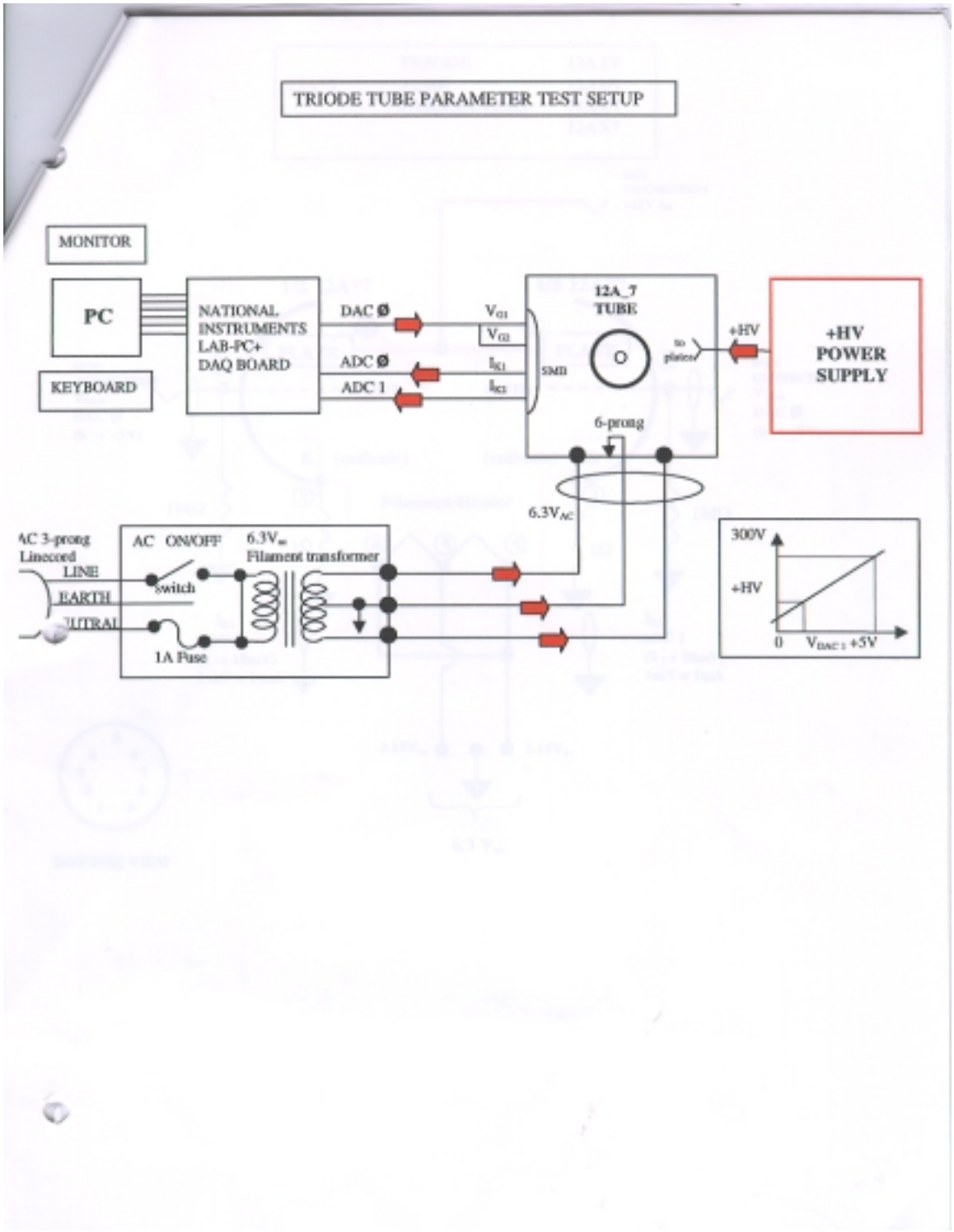
The Groove Tube characteristics are very close in value to the values given in Mr. Mitchell's book when both sides of the tube data are averaged together. The same type of agreement was found when RCA 7025_6452 was compared with values in Rodney Faber's *Introduction to Amplifiers* which was published in 1968.[2] It is interesting to note that though the 12AX7 tubes have two sides all data found in various books only shows one curve per plate voltage setting.

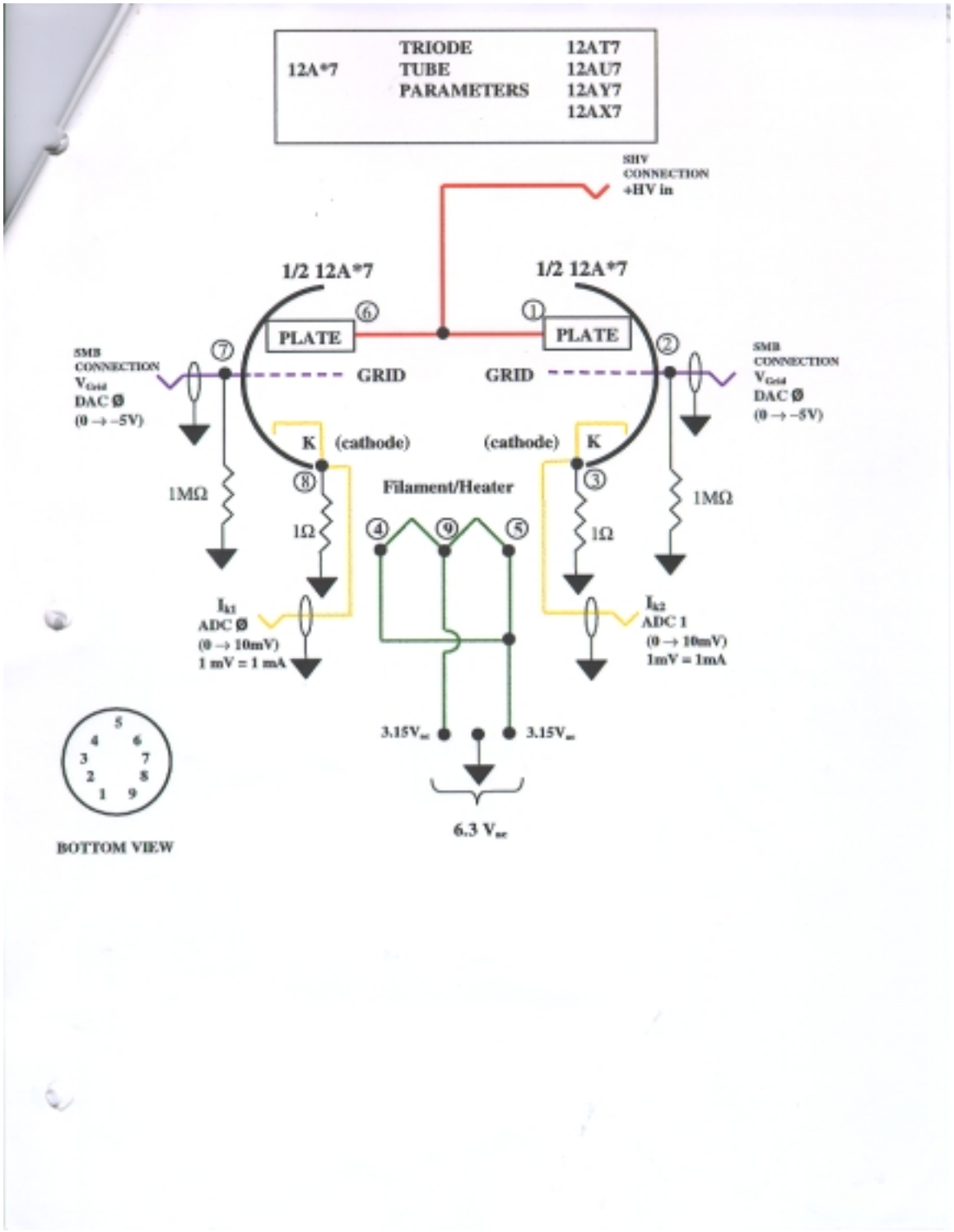
RCA_7025_6435 may have experienced a mishap sometime in its 30-year lifetime. One possible explanation of it not conforming to the published values for tubes in its age group it that the separation between the grid and the

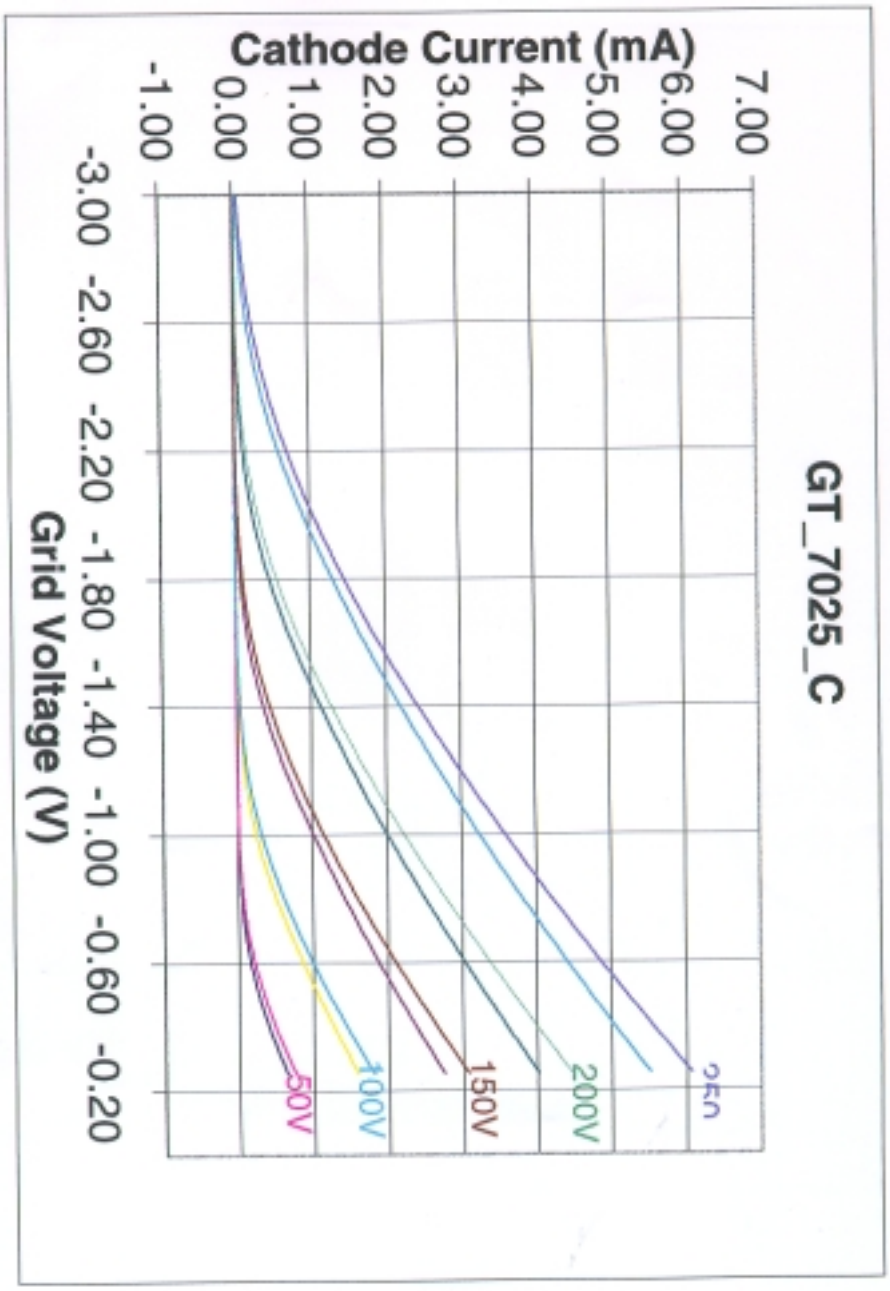
cathode on one side has widened and the magnetic field between the two components has weakened.

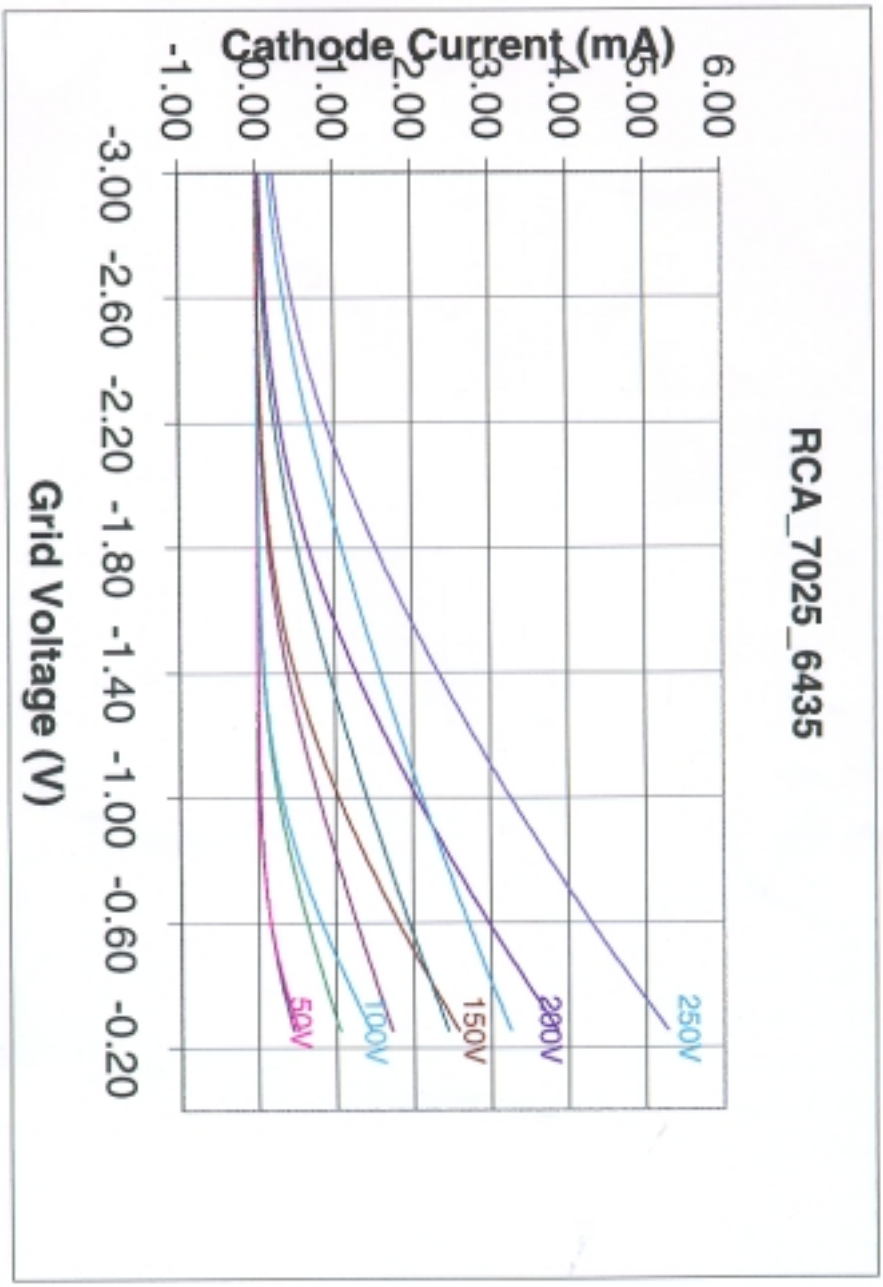
CONCLUSION

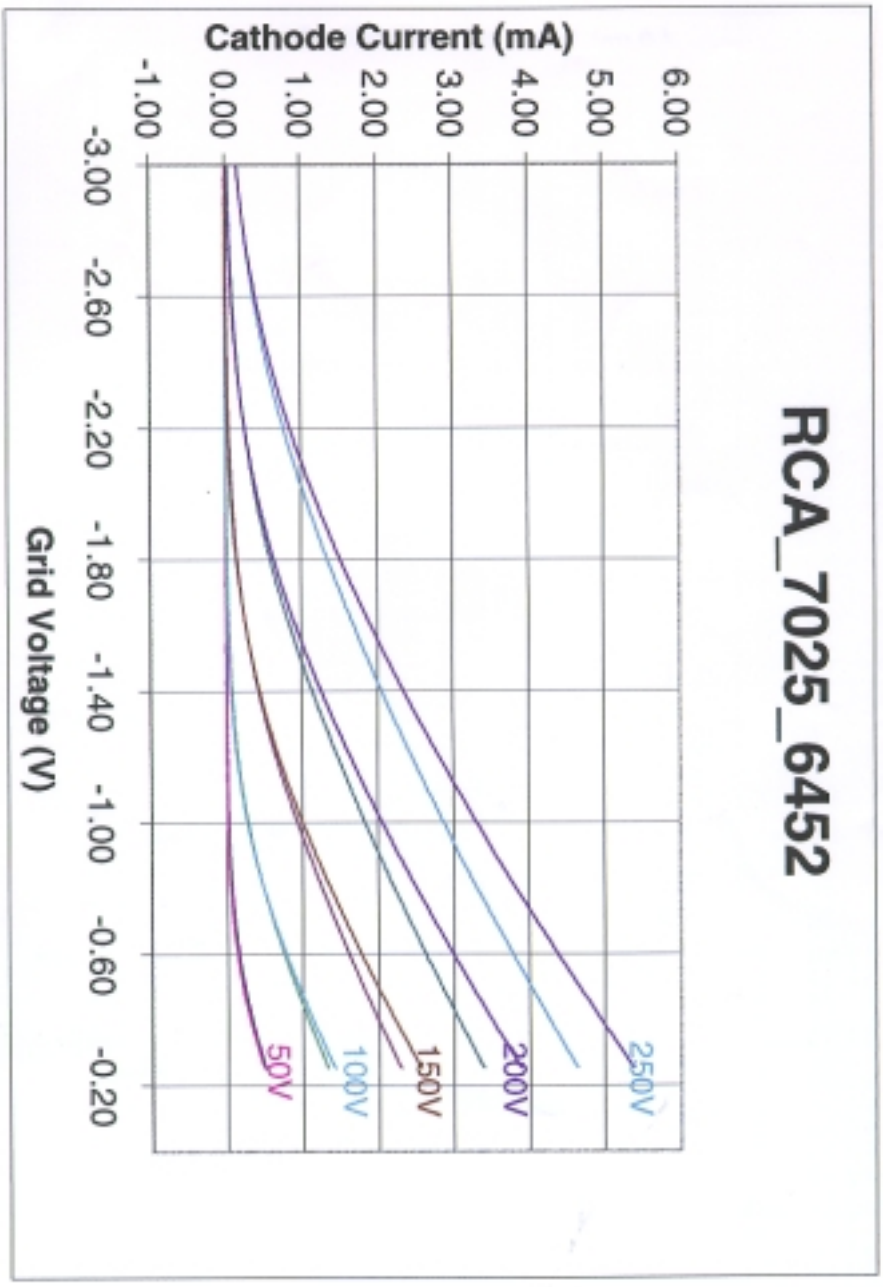
Characteristics of new and old tubes are remarkably similar. The measured values of two of the tubes conform to the published values when the two sides are averaged. The third tube, RCA_7025_6435 has one side that agrees in measurement with RCA_7025_6452, and one side that has considerable less output current suggesting that it is no longer within specifications for audio applications.

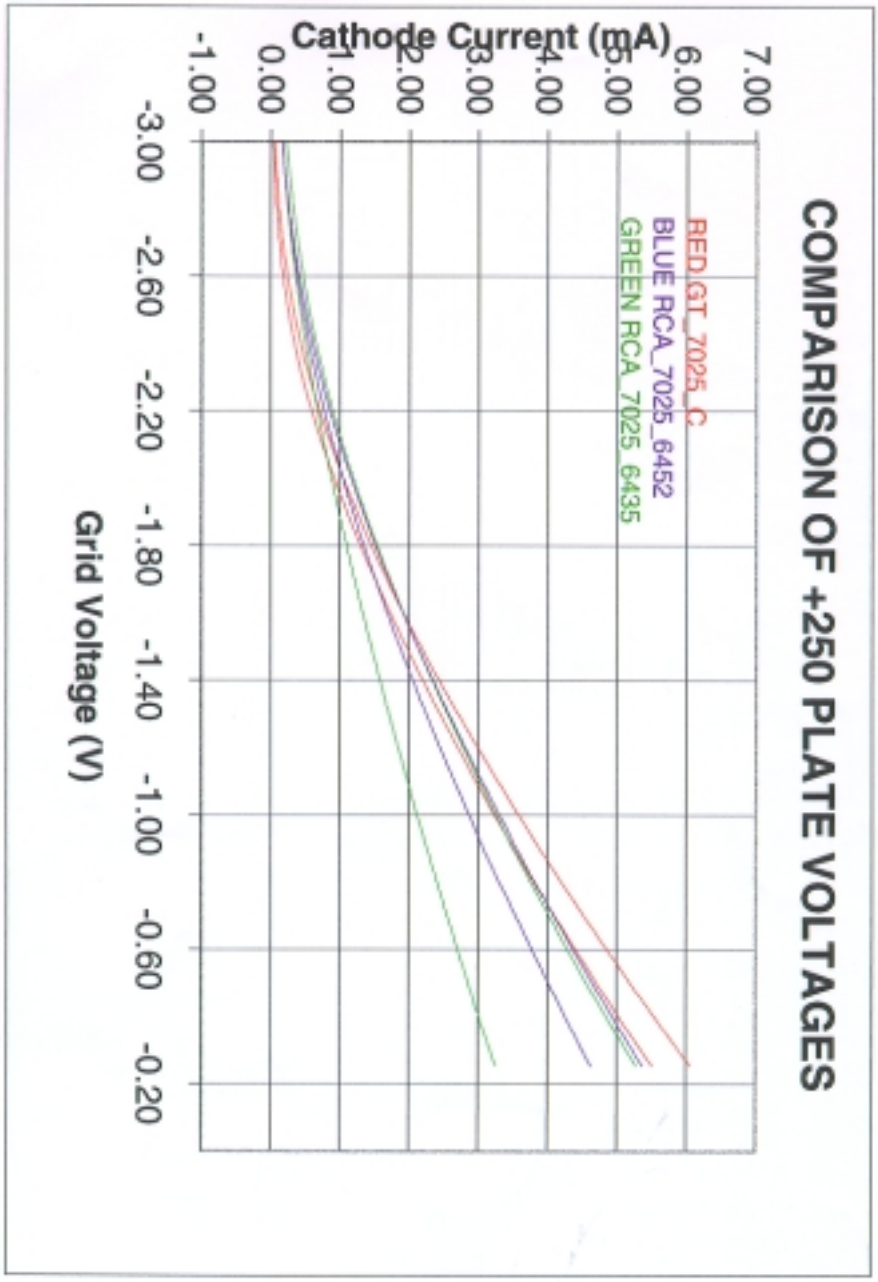

TRIODE TUBE PARAMETER TEST SETUP
MONITOR
PC
KEYBOARD
NATIONAL
INSTRUMENTS
LAB-PC+
DAQ BOARD
DAC Ø
ADC Ø
ADC 1
V_{G1}
V_{G2}
I_{K1}
I_{K2}
12A_7
TUBE
SMB
to
plates
+HV
+HV
POWER
SUPPLY
6-prong
$6.3V_{AC}$
AC 3-prong
Linecord
LINE
EARTH
NEUTRAL
AC ON/OFF
switch
1A Fuse
$6.3V_{ac}$
Filament transformer
300V
+HV
0
$V_{DAC\,1}$ +5V


12A*7
TRIODE
TUBE
PARAMETERS
12AT7
12AU7
12AY7
12AX7
SHV
CONNECTION
+HV in
1/2 12A*7
1/2 12A*7
PLATE
PLATE
GRID
GRID
SMB
CONNECTION
V_{Gx4}
DAC Ø
(0 → −5V)
SMB
CONNECTION
V_{Gx4}
DAC Ø
(0 → −5V)
K (cathode)
(cathode) K
1MΩ
1Ω
Filament/Heater
1Ω
1MΩ
I_{k1}
ADC Ø
(0 → 10mV)
1 mV = 1 mA
I_{k2}
ADC 1
(0 → 10mV)
1mV = 1mA
3.15V_{ac}
3.15V_{ac}
6.3 V_{ac}
BOTTOM VIEW

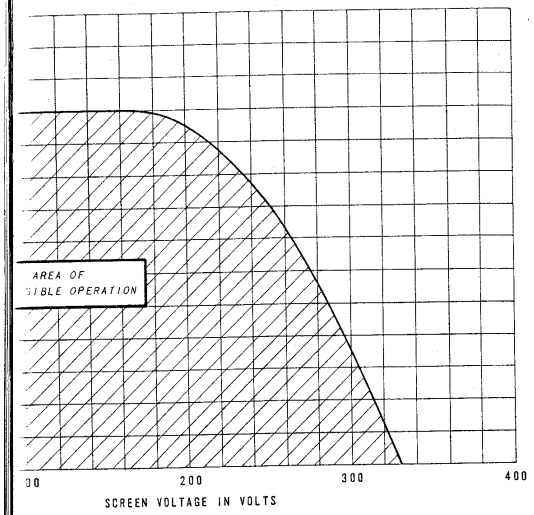

GT_7025_C
Cathode Current (mA)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-3.00 -2.60 -2.20 -1.80 -1.40 -1.00 -0.60 -0.20
Grid Voltage (V)
250
200V
150V
100V
50V


RCA_7025_6435
Cathode Current (mA)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-3.00 -2.60 -2.20 -1.80 -1.40 -1.00 -0.60 -0.20
Grid Voltage (V)
250V
200V
150V
100V
50V

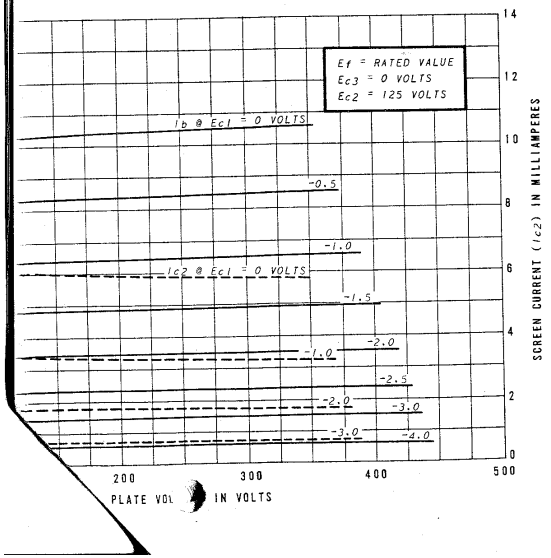

RCA_7025_6452
Cathode Current (mA)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
Grid Voltage (V)
-3.00
-2.60
-2.20
-1.80
-1.40
-1.00
-0.60
-0.20
250V
200V
150V
100V
50V


COMPARISON OF +250 PLATE VOLTAGES
Cathode Current (mA)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
RED GT_7025_C
BLUE RCA_7025_6452
GREEN RCA_7025_6435
-3.00
-2.60
-2.20
-1.80
-1.40
-1.00
-0.60
-0.20
Grid Voltage (V)

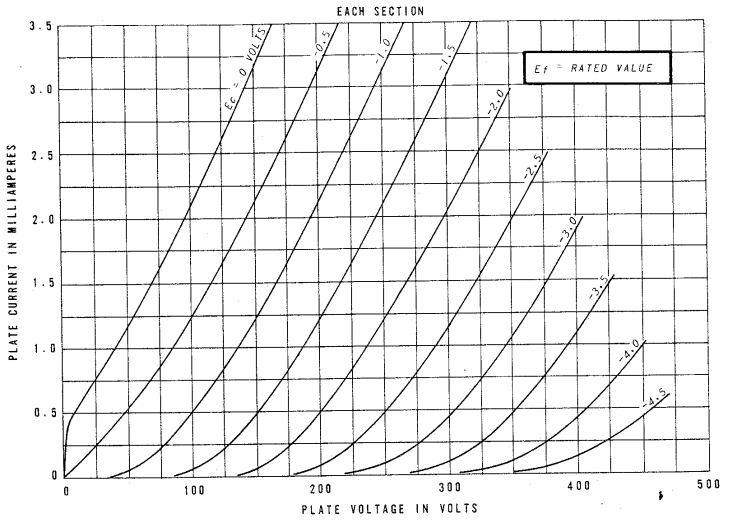
Screen Rating Chart — 6CB6-A



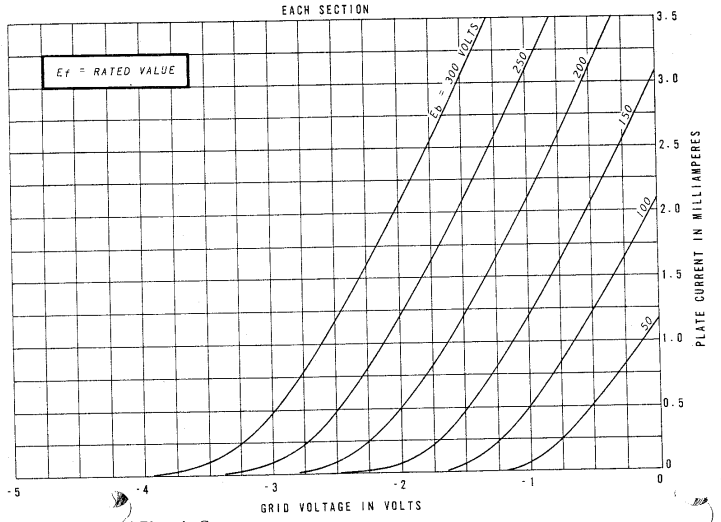
Average Plate Characteristics



Average Plate Characteristics — 12AX7-A



Average Transfer Characteristics



SOURCE: General Electric Company