ANALOG ENGINEERING ASSOCIATES

Certified Tube Performance Report™

Detailed laboratory quality analysis of performance under actual operating conditions present in your amplifier

Tube Type: 2X Mullard EL84 / 6BQ5 (vintage)

Test Date: _____________ **Specified Reference Amplifier:** Dynaco SCA-35

Notes: *Hammond OEM branded pair of Amperex EL84/6BQ6. Good cosmetic condition.*
Codes: Tube 1- rx4-delta-3G3 Tube 2- rx4-delts-1L4

Conclusions and Recommendations:

Not recommended for use as a matched pair
>>Curve Tracer shows pair is out of match by 7% at full operating voltage. (Proper match is less than 5%)

*Both tubes test strong with no leakage currents or shorts. Operating parameter curves are normal. Life test is 98+%. Noise and microphonics are good. ** See recommended bias setting section*

Details of Tube Parameter Test Results

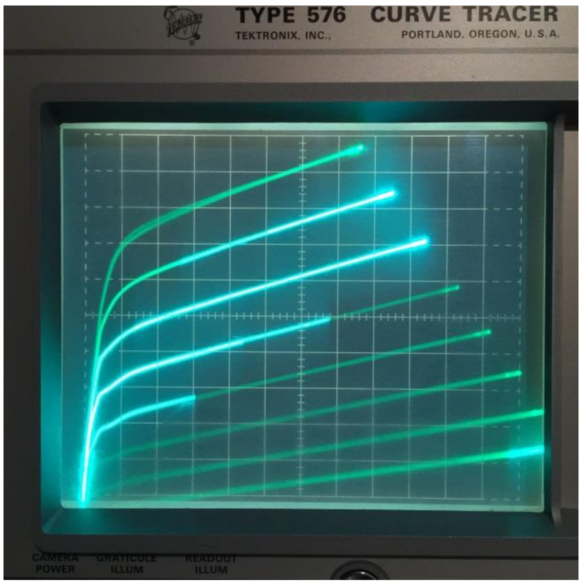
Tube Type: EL84 / 6BQ5 (vintage)			**Tube 1 (if matched pair)**		**Tube 2 (if matched pair)**	
Test Parameter		**Manufacturer's Specification**	**Section A Test Result**	**Section B Result**	**Section A Result**	**Section B Result**
Plate Volts	Ep Vdc	300	300		300	
DC Plate Current	Ip mAdc	15	14.5		14	
AC Plate Current	Ip mAac	92	92		90	
Screen Volts	G2 Vdc	300	300		300	
Screen Current	IG2 mA	22	23		21	
Bias Volts	G1 Vdc	-14	-14		-14	
Test Signal Volts (MAX)	RMS	28.2	24.4		24.4	
Mutual Conductance	uMhos	11300	11550		11500	
Mutual Conductance	%	100%	102.2%		102.0%	
Life Test (% uMhos after 10% heater voltage reduction)		100%	97%		98%	
Grid #1 Leakage	uA	0	0		.01	
H/K Leakage	mA	0	0		0	
Plate Resistance	RP Ohms	40000	38560		37720	
Tube Gain	Mu	N/A	126		124	
Heater Voltage	eF Vdc	6.3	6.3		6.3	
Heater Warmup Time	Sec	11	12		12	

Curve Tracer Testing Results

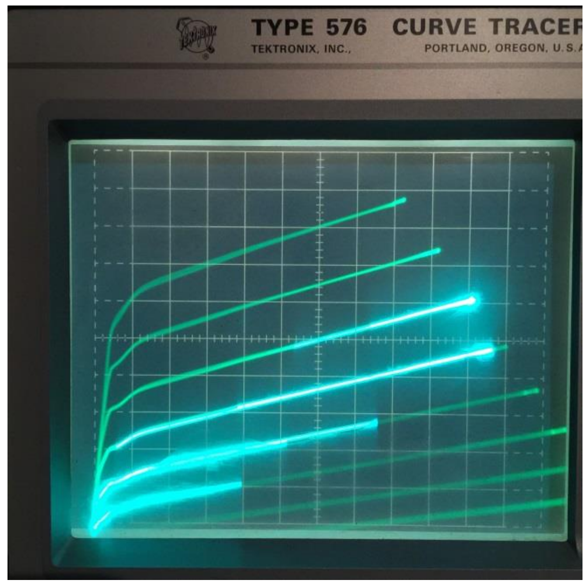
Performance Curves and Tube Matching Under Full Operating Conditions

In order to accurately measure a tube's operating parameters under 'real-world' conditions we perform curve tracing at voltages and loads that duplicate the tube's actual operating environment.

The plate voltages and load resistance used to plot the curves below have been set to either the manufacturer's data book recommendations or to the actual operating voltages and plate load of the target amplifier whenever that information is available. The traces are positioned on the screen such that the target amplifier's indicated operating voltage and optimum plate current is exactly at the center of the display. This allows quick comparison measurements when matching tubes.



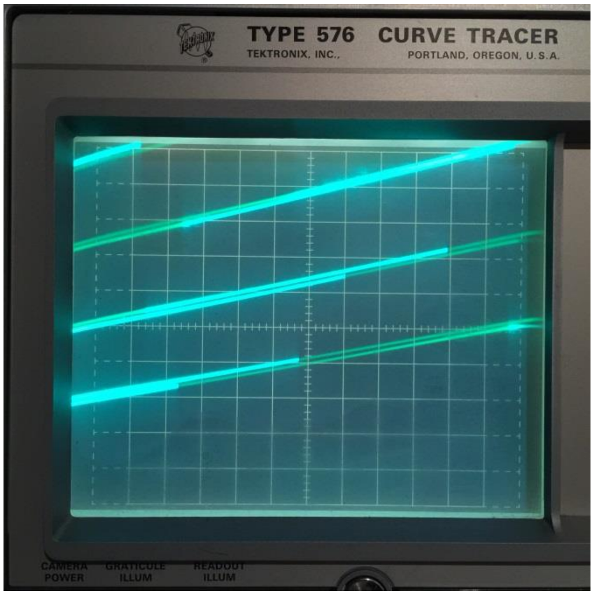
TUBE 1



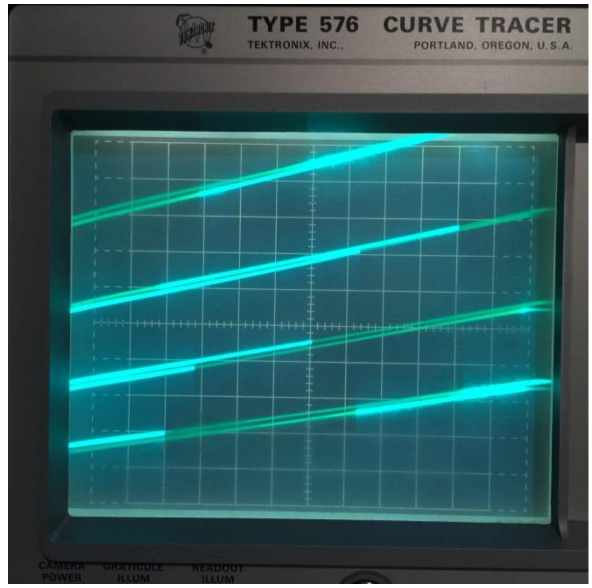
TUBE 2

Ultimate Bias Setting

By close examination of a particular tube's performance curves over the tube's actual operating range, it is possible to find the optimum bias voltage when the plate and screen voltages, output load and maximum output current are known. The target amplifier's indicated operating voltage and optimum plate current is set exactly at the center of the display. This allows quick identification of the optimum bias voltage and current.



TUBE 1



TUBE 2

The operating curves above measure the characteristic of each tube throughout its operating range to further refine measurements in order to find the optimum bias settings for each individual tube in the above specified reference amplifier.

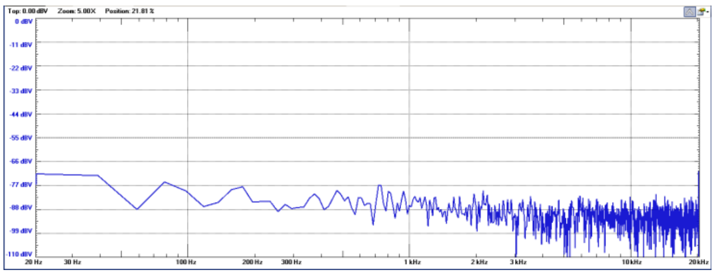
		Tube 1		**Tube 2**		**Recommended Bias Setting For Pair***
Bias Setting	**Manufacturer's Recommended**	**Optimum Indicated**	**% Change**	**Optimum Indicated**	**% Change**	* This is the recommended bias setting when adjustment can only be made for each channel pair, or for all tubes.
Grid Voltage Vdc	.35 V	.27	22%	.29	17%	2.8 V (curves indicate tubes are best adjusted equal mid-point bias)
Plate Current mAdc	35 mA	27mA	22%	29 mA	17%	28 mA (curves indicate tubes are best adjusted equal mid-point bias)

Noise and Microphonics Test

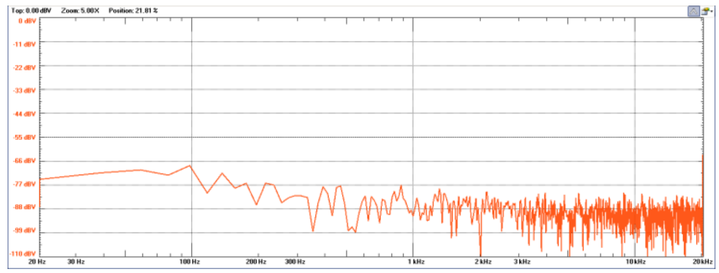
The spectrum analyzer graphs below show each tube's noise and microphonic output.

Noise tests are performed by placing the tube in a high-gain, high-bandwidth amplifier stage with a 100 kOhm low-noise metal film resistor terminating the control grid(s). 6BQ5 acceptable noise level is below -55 dB across entire spectrum

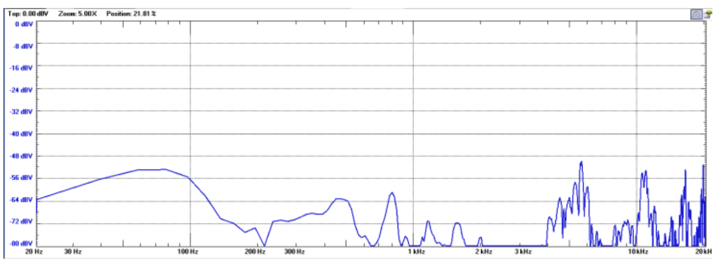
Microphonic tests are performed by subjecting the tube to a white noise signal at 100 dB sound pressure level while in the noise test fixture. 6BQ5 acceptable noise level is below -45 dB across entire spectrum.



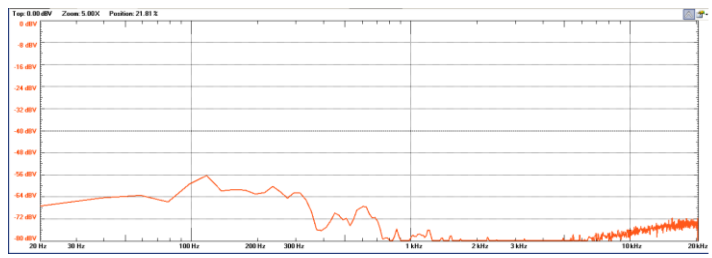
Tube 1 Noise Spectrum Level



Tube 2 Noise Spectrum



Tube 1 Microphonic Spectrum Level



Tube 2 Microphonic Spectrum Level

Results Analysis:

Noise and microphonics are marginally within good performance levels for both tubes.

Tube 1 has notable microphonics above 1000 Hz indicating control of screen grid movement. This should not be a problem in most power output applications.

Why

Vacuum tube curve tracers are rare compared to tube testers. They are complex, expensive laboratory type instruments, and require considerable training for proper use. However, the added effort is well worth it. Unlike tube testers that can only show simple characteristic such as transconductance at only one operating point, curve tracers show you all operating parameters across all operating conditions – all at once.

Only a curve tracer can properly perform tests such as matching a pair of audio tubes, or determining if a power tube is capable of providing it's full rated output power in a particular amplifier, or determining a tube's optimum bias point for a given circuit design.

For repair work a simple test on a tube tester to find out if a particular tube is serviceable (good or bad) is sufficient. That's what they were designed to do. But when you need detailed information about a tube's performance under actual operating conditions, a curve tracer is the only practical way to find it. That's what curve tracers were designed to do.

When it comes to tasks like matching tubes, a tube tester's single point comparison of transconductance, plate current or other parameters can be very misleading. Correctly matching tubes is greatly simplified when you can see the transconductance, plate resistance and plate current graphically represented over the tube's entire operating range of plate and grid voltages. Additionally, with a curve tracer, detailed A-B comparisons between two tubes can be made visually with the throw of a switch.

Curve tracers can also provide an extremely accurate evaluation of a tube's condition through direct comparisons to the performance curves published in manufacturer's data sheets.

We currently use two curve tracers:

A Tektronics 576 manually operated tracer. It has been modified especially for audio tube curve tracing with the capability to plot transconductance and amplification factors over a wide range of grid, plate and screen voltages – up to 1,500 volts at up to 220 watts output.

A uTracer model 3+ fully computerized (software driven) tracer. It has also been modified allowing us to precisely duplicate the operating conditions of any amplifier (up to 480 volts and 50 watts per tube). It can simulate the exact grid, cathode and plate circuit conditions found in your amp, allowing us to test your tubes in their true operating environment.

How

In most graphs the vertical scale is the plate current, the horizontal scale is the plate voltage – just like the curves in a tube manual. Each curve in the set or "family" shows a plot of the plate current from zero to maximum operating volts on the plate for a fixed value of grid bias. The combined family of curves displayed show the plate current for grid bias from zero to maximum in graduated voltage steps.

The graph of curves lets you measure the plate current at any plate voltage for any given grid bias and compare them to datasheet values. A measure of the change in plate current for a change in grid bias is the transconductance. Graphically this is displayed as the distance from any given curve to the next one at a fixed plate voltage (the vertical lines on the graph).

The transconductance in micromhos is determined at any given plate and grid voltage by counting the number of divisions between two curves at a fixed plate voltage and multiplying by the scale factor.

The change in plate current for a change in plate voltage at a fixed grid bias is the plate resistance. The slope of the curves indicates the amount of plate resistance. Curves with a sharp upward slope show a low resistance since the plate current goes up quickly with plate voltage.

Zeroing in on transcendence and linearity

From the spacing between the curves you can see how linear the transconductance (gain) is over the range of operating points. The family of curves should show uniform spacing of the curves one to another. While this is useful, you can measure the tube's linearity more directly on a transconductance plot.

By plotting the grid voltage on the horizontal axis against the plate current on the vertical axis, a transconductance curve family is produced. Each of the curves is now a vertical line of varying height representing the plate current for each value of grid bias at the selected operating voltage. You simply "connect the dots" of the tops of the lines to visualize the transconductance curve.

With this type of plot you can see where the transconductance is most linear in relation to grid bias. The optimum bias point will be in the most linear area of the curve.

The absolute value of the transconductance can also be determined in the same way as with the plate current curve family. Simply measure the number of divisions of vertical distance from one line tip to the next and multiply that times the scale factor set on the curve tracer. By adjusting the peak plate voltage up or down you can observe the values and the linearity of the transconductance at any plate voltage (and plate current) for comparison.

The results of the transconductance test are highly dependent on the grid bias and plate voltage – showing why no two single point "tube testers" will ever give you the exact same value of transconductance.

To show the tube's variation from the data sheet's published transconductance value, you simply use the same voltages and currents given in the data sheet. Then you have the real answer to what condition the tube is in. For a good tube the curves should look very much like the data sheet and be very close to the values printed on its graphs. A bad or week tube will show low plate currents and weak transconductance. A "leaky" tube will often show lines sloping downward compared to the data sheet's curves.

6BQ5-8BQ5

PENTODE

FOR AF POWER AMPLIFIER APPLICATIONS

DESCRIPTION AND RATING

The 6BQS is a power-amplifier pentode designed for use in the audio-frequency power-output stage of television and radio receivers and in high-fidelity amplifiers.

Except for heater ratings, the 8BQS is identical to the 6BQS.

GENERAL

ELECTRICAL

Cathode-Coated Unipotential	6BQ5	8BQ5	
Heater Voltage, AC or DC	6.3	8.0	Volts
Heater Current	0.76	0.6	Amperes
Heater Warm-up Time*		11	Seconds

Direct Interelectrode Capacitancest

Grid-Number 1 to Plate, maximum	0.5	μμf
Input	10.8	μμf
Output	6.5	μμf

MECHANICAL

Mounting Position-Any
Envelope-T-6½, Glass
Base-E9-1, Small Button 9-Pin

MAXIMUM RATINGS

DESIGN-CENTER VALUES

Plate Voltage	300	Volts
Screen Voltage	300	Volts
Negative DC Grid-Number 1 Voltage	100	Volts
Plate Dissipation	12	Watts
Screen Dissipation (Continuous)	2.0	Watts
Screen Dissipation (Peaks of Speech and Music)	4.0	Watts
DC Cathode Current	65	Milliamperes
Heater-Cathode Voltage		
Heater Positive with Respect to Cathode	100	Volts
Heater Negative with Respect to Cathode	100	Volts
Grid-Number 1 Circuit Resistance		
With Fixed Bias	0.3	Megohms
With Cathode Bias	1.0	Megohms

Design-Center ratings are limiting values of operating conditions applicable to a bogey tube of a specified type as defined by its published data, and should not be exceeded under normal conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation (For an AC power source, 117 volts plus or minus 10% is accepted USA practice.), equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in tube characteristics.

The equipment manufacturer should design so that initially no design-center value for the intended service is exceeded with a bogey tube in equipment operating at the stated normal supply voltage.

GENERAL ELECTRIC

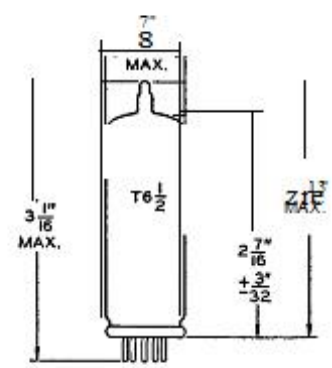
BASING DIAGRAM

EIA9CV

TERMINAL CONNECTIONS

Pin 1-Internal Connection
Pin 2-Grid Number 1
Pin 3-Cathode and Grid Number 3 (Suppressor)
Pin 4-Heater
Pin 5-Heater
Pin 6-Internal Connection
Pin 7-Plate
Pin 8-Internal Connection
Pin 9-Grid Number 2 (Screen)

PHYSICAL DIMENSIONS



EIA 6-4

CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS

Plate Voltage	250	Volts
Screen Voltage	250	Volts
Grid-Number 1 Voltage	−7.3	Volts
Plate Resistance, approximate	40000	Ohms
Transconductance	11300	Micromhos
Plate Current	48	Milliamperes
Screen Current	5.5	Milliamperes
Amplification Factor (Grid-Number 1 to Grid-Number 2)	19.5	

CLASS A_1 AMPLIFIER

Plate Voltage	250	250	250	250	Volts
Screen Voltage	250	250	250	210	Volts
Grid-Number 1 Voltage	−7.3	−7.3	−8.4	−6.4	Volts
Peak AF Grid-Number 1 Voltage	6.1	6.2	4.95	4.8	Volts
Zero-Signal Plate Current	48	48	36	36	Milliamperes
Maximum-Signal Plate Current	49.5	50.6	36.8	36.6	Milliamperes
Zero-Signal Screen Current	5.5	5.5	4.1	3.9	Milliamperes
Maximum-Signal Screen Current	10.8	10	8.5	7.3	Milliamperes
Load Resistance	5200	4500	7000	7000	Ohms
Total Harmonic Distortion, approximate	10	10	10	10	Percent
Maximum-Signal Power Output	5.7	5.7	4.2	4.3	Watts

PUSH-PULL CLASS AB_1 AMPLIFIER, VALUES FOR TWO TUBES

Plate Voltage	250	300	Volts
Screen Voltage	250	300	Volts
Cathode-Bias Resistor	130	130	Ohms
Peak AF Grid-to-Grid Voltage	22.6	28.2	Volts
Zero-Signal Plate Current	62	72	Milliamperes
Maximum-Signal Plate Current	75	92	Milliamperes
Zero-Signal Screen Current	7.0	8.0	Milliamperes
Maximum-Signal Screen Current	15	22	Milliamperes
Effective Load Resistance, Plate-to-Plate	8000	8000	Ohms
Total Harmonic Distortion	3	4	Percent
Maximum-Signal Power Output	11	17	Watts

PUSH-PULL CLASS B AMPLIFIER, VALUES FOR TWO TUBES

Plate Voltage	250	300	Volts
Screen Voltage	250	300	Volts
Grid-Number 1 Voltage	−11.6	−14.7	Volts
Peak AF Grid-to-Grid Voltage	22.6	28.2	Volts
Zero-Signal Plate Current	20	15	Milliamperes
Maximum-Signal Plate Current	75	92	Milliamperes
Zero-Signal Screen Current	2.2	1.6	Milliamperes
Maximum-Signal Screen Current	15	22	Milliamperes
Effective Load Resistance, Plate-to-Plate	8000	8000	Ohms
Total Harmonic Distortion	3	4	Percent
Maximum-Signal Power Output	11	17	Watts

CLASS A_1 AMPLIFIER, TRIODE CONNECTION‡

Plate Voltage	250	Volts
Cathode-Bias Resistor	270	Ohms
Peak AF Grid-Number 1 Voltage	9.5	Volts
Zero-Signal Plate Current	34	Milliamperes
Maximum-Signal Plate Current	36	Milliamperes
Load Resistance	3500	Ohms
Total Harmonic Distortion, approximate	9	Percent
Maximum-Signal Power Output	1.95	Watts

CHARACTERISTICS AND TYPICAL OPERATION (Continued)

PUSH-PULL CLASS AB_1 AMPLIFIER TRIODE CONNECTION, VALUES FOR TWO TUBES‡

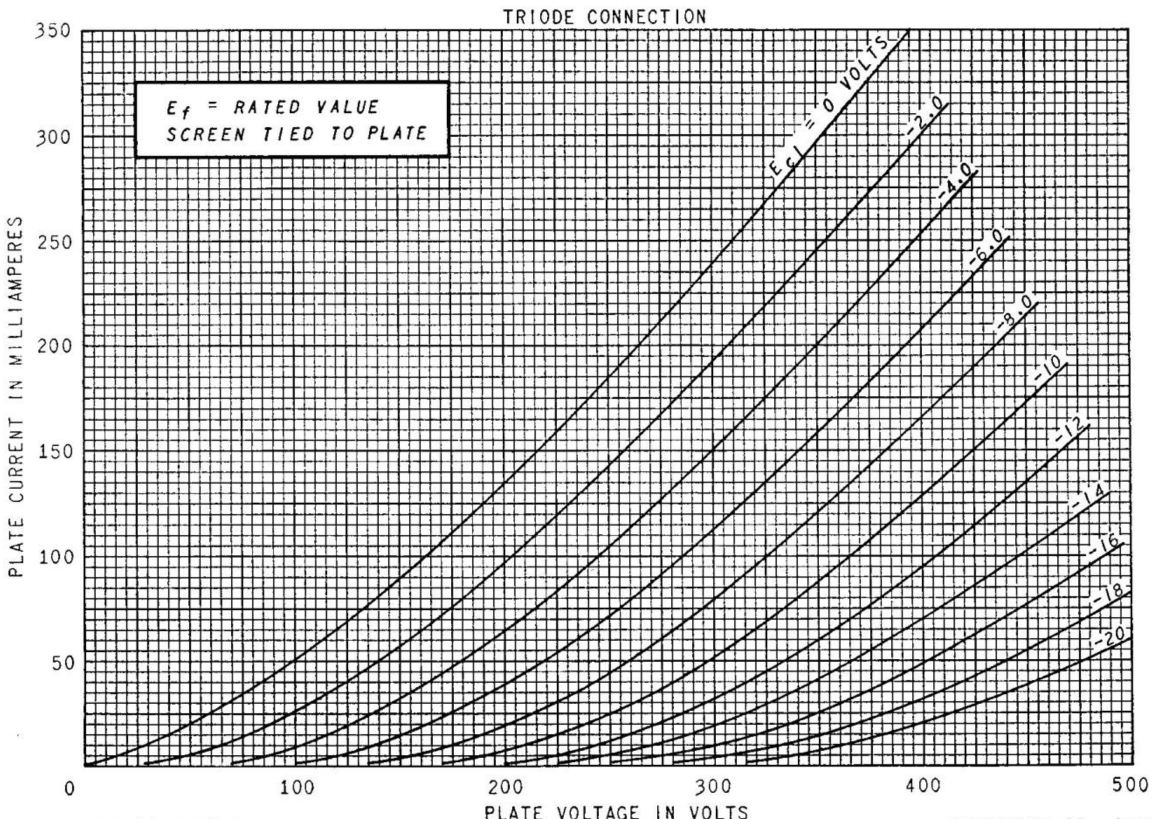
Plate Voltage	250	300	Volts
Cathode-Bias Resistor	270	270	Ohms
Peak AF Grid-to-Grid Voltage	23.4	28.2	Volts
Zero-Signal Plate Current	40	48	Milliamperes
Maximum-Signal Plate Current	43.4	52	Milliamperes
Effective Load Resistance, Plate-to-Plate	10000	10000	Ohms
Total Harmonic Distortion	2.5	2.5	Percent
Maximum-Signal Power Output	3.4	5.2	Watts

* The time required for the voltage across the heater to reach 80 percent of its rated value after applying 4 times rated heater voltage to a circuit consisting of the tube heater in series with a resistance equal to 3 times the rated heater voltage divided by the rated heater current.

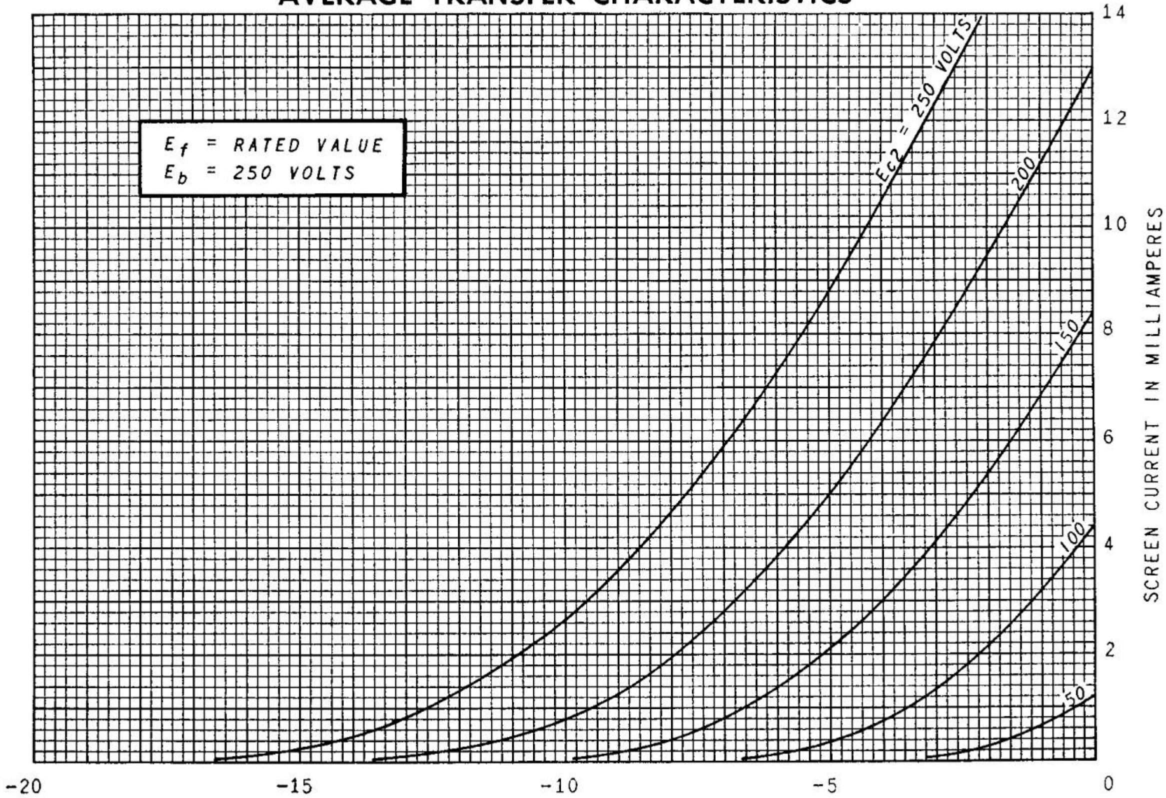
† Without external shield.

‡ With screen tied to plate.

AVERAGE PLATE CHARACTERISTICS

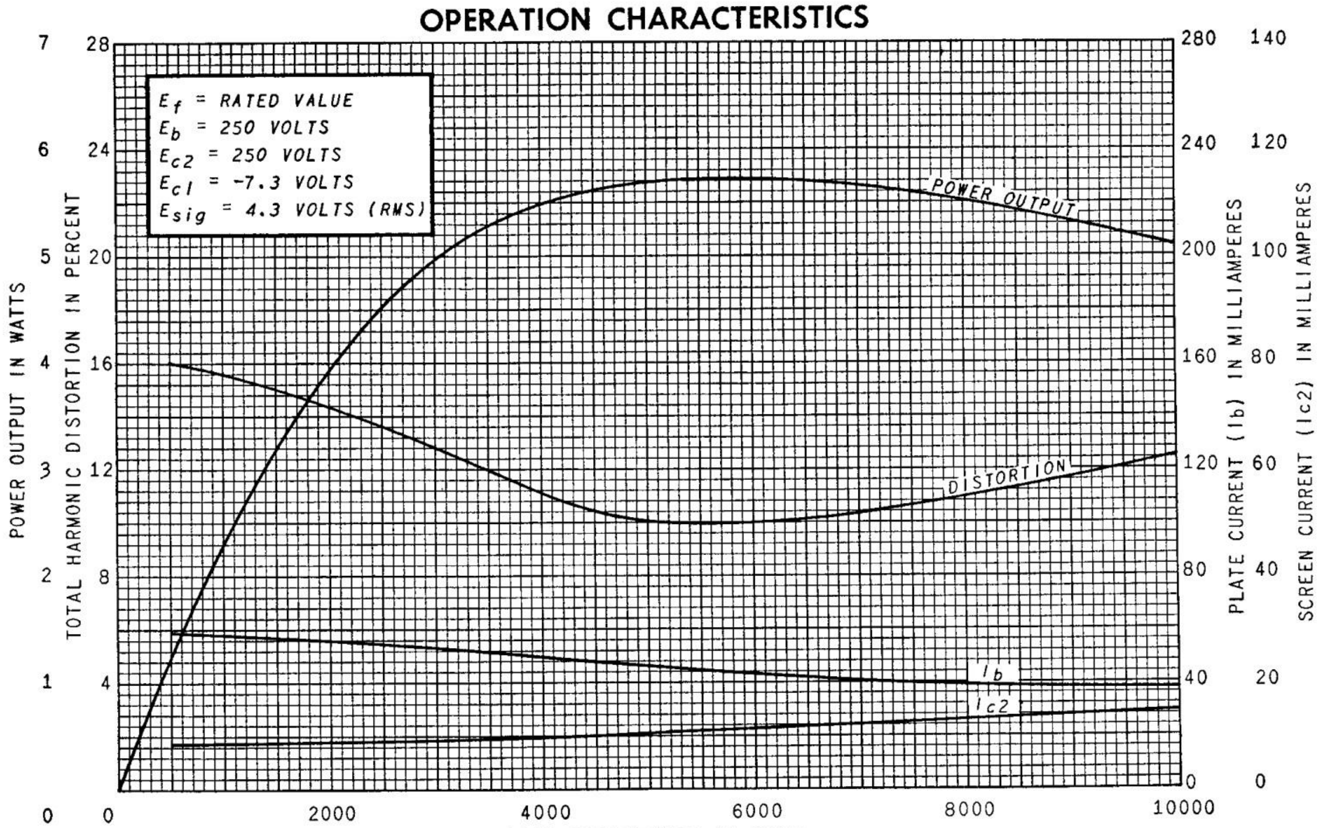


AVERAGE TRANSFER CHARACTERISTICS



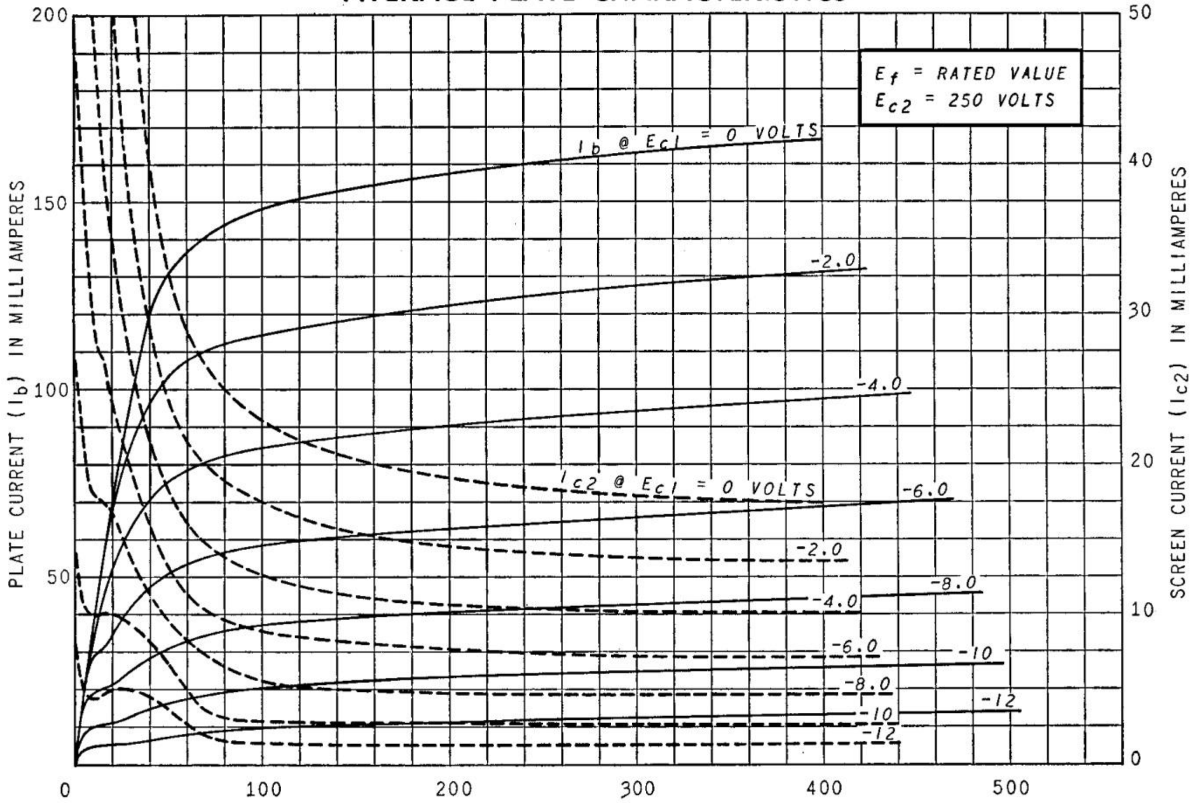
K-55611-TD52-4 DECEMBER 23, 1958

OPERATION CHARACTERISTICS



K-55611-TD52-5 DECEMBER 17, 1958

AVERAGE PLATE CHARACTERISTICS



K-55611-TD52-2 DECEMBER 17, 1958

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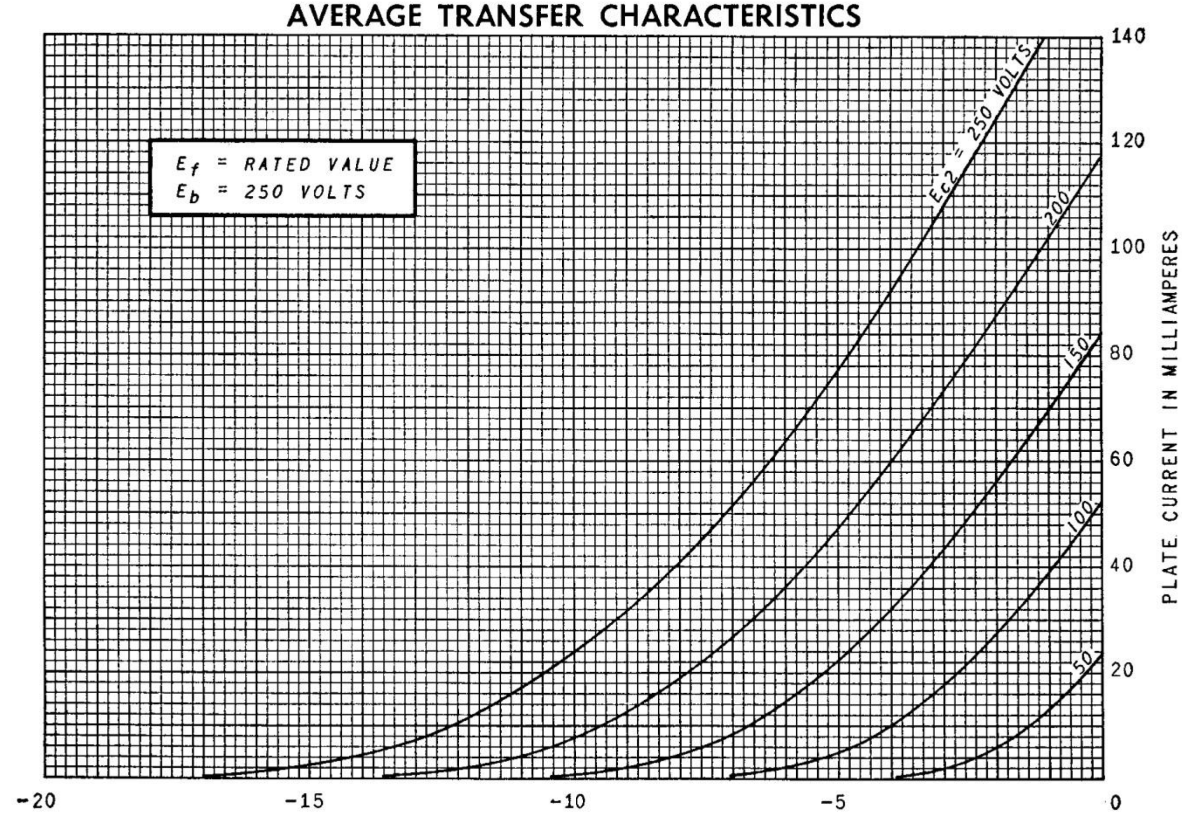
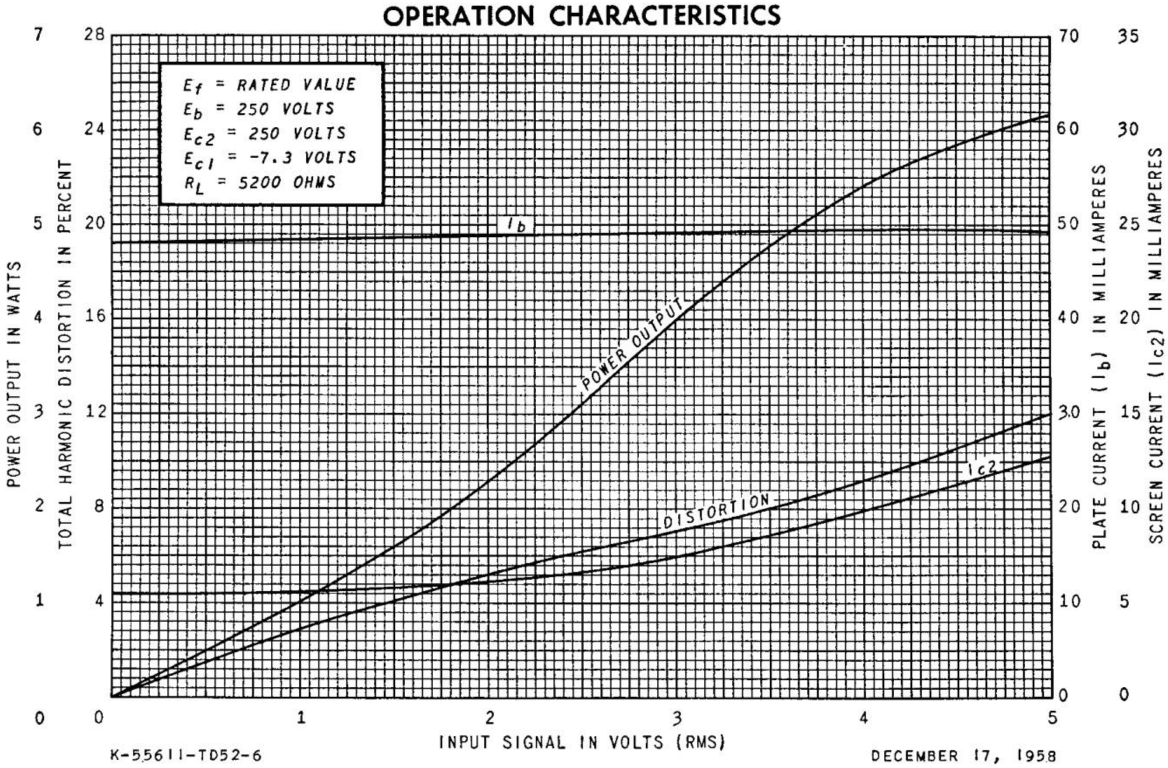
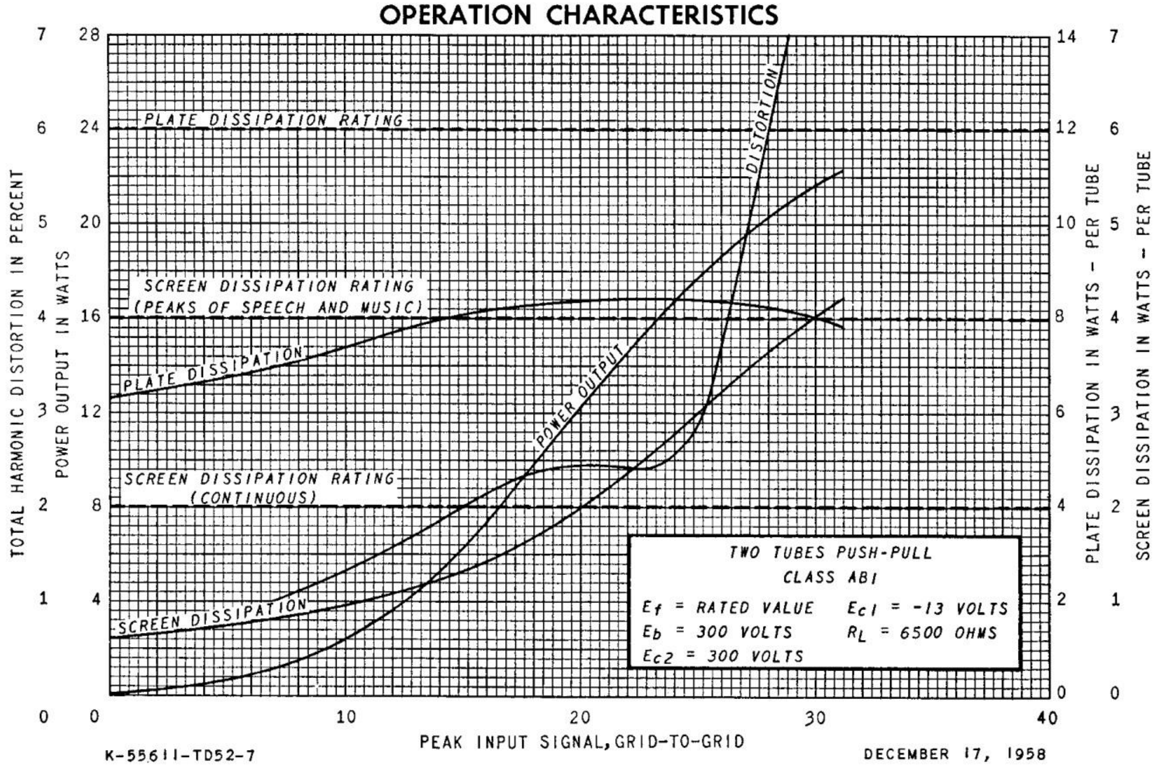


K-55611-TD52-3 DECEMBER 23, 1958

OPERATION CHARACTERISTICS



OPERATION CHARACTERISTICS



ELECTRONIC COMPONENTS DIVISION

GENERAL ELECTRIC

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