

INTRODUCTION:

This paper is part 1 of a series that addresses the 6146B specifically and Beam type tubes in general.

The 6146B was introduced in the mid-60's to compete with the sweep tubes that had become extraordinarily inexpensive as tubed TV's faded into history.

A pair of sweep tubes could replace up to five 6146's with no loss of linearity costing a fraction of the price of a 6146. There is a notion held by some that have a financial interest in the 6146 and others who find it impossible to accept changing technology insisting that sweep tubes are less linear than the 6146; none of which is true. What is true is the design practices required to implement sweep tubes is more complex and rigid than for a 6146.

The tube data sheets would have you believe the 6146B is a plug compatible tube for the 6146 having essentially the same inter-electrode capacities and bias characteristics --- simply more plate dissipation. This is an absurd mischaracterization of the 6146B. If it were true the following reports would not have been voiced.

It works flawlessly in my radio!

I can't neutralize it in my radio!

The bias has to be set higher to idle!

I was in a QSO when there were sparks inside and a hole melted in the glass!

The neutralizing capacitor burned up!

My radio goes into oscillation and pegs the plate meter!

Etc. etc. etc.

The fact that they generally need more feedback to neutralize and more bias to idle would suggest the data sheets are questionable at best and likely misstated.

The following information is not new. It is simply organized to connect the dot points in a way that clarifies the reasons surrounding the 6146B's behavior, and further, to clear the misunderstanding of sweep tubes.

BEAM TYPE TUBES:

In order to understand the reasons for the strange reported behaviors of the 6146B we have to review the essence of the beam type tube family.

First, what is a beam type tube and why it is different from any other tube type i.e. a sharp or remote cutoff pentode or for that matter any other screen grid tube.

RCA developed the BEAM type tube to address the limitations and inadequacies of tetrode power tubes. The objectives were to provide a high level of output, limit screen current, minimize inter-electrode capacity, and eliminate the suppressor grid.

Characteristics of Beam type tubes:

Some have Beam forming plates and some do not!

Beam type tubes that have a flat anode i.e. the 6146, 807, 6AQ5, and others use beam forming plates to confine the electron cloud to an area directly between the cathode and anode while directing it away from the mounting posts for the control and screen grids.

Circular beam tubes i.e. the 4-400, 8122, 4-125, 4CX400 and others do not have beam forming plates.

Beam type tubes DO NOT use a suppressor grid; they create a virtual cathode/suppressor grid between the screen and plate. Some data sheets would have you think there is a suppressor grid but the connection is to the beam forming plates.

Beam forming plates are also used by some non-beam type tubes i.e. the 6BZ6, 12DK6, and other small signal class A tubes because the negative peak of the plate envelope is not expected to reach the screen potential.

The negative peak of the plate envelope in beam type tubes can drop very close to the screen voltage before a marked increase in screen current occurs.

How is a Beam type tube different from others?

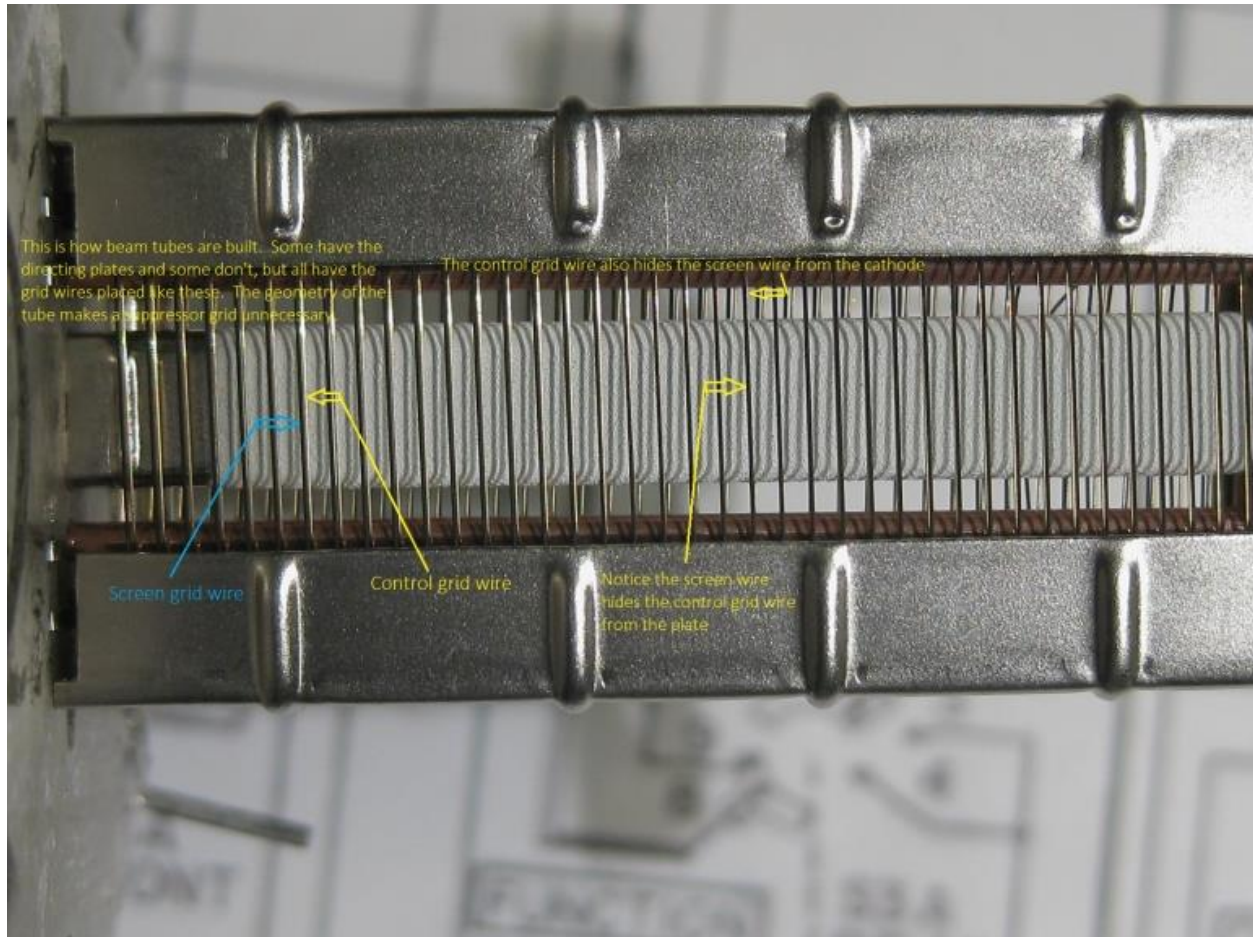
The beam forming plates DO NOT define a beam type tube, they can be found in all sorts of tubes. The Beam type tube is differentiated from other tubes by implementing a number of **individual beam channels** . The 6146 has approximately 34 individual channels and the 6KD6 about 85.

WHAT IS A BEAM CHANNEL?

The following photo is a dissected 6146 showing the beam forming plates on the top and bottom, shielding the CG and SG mounting posts. Note how the beam forming plates hide the

CG and SG mounting posts. Also note how it's difficult to see the CG wires because they are hidden behind the SG wires.

There is a beam channel between each grid pair.



The control and screen grid wires are precision aligned. Looking from the cathode to the anode you will see only the control grid because the screen wire is directly behind the control grid wire and from anode to cathode only the screen wire will be visible.

Between control grid wires will be a beam channel. When the control grid is negative the electrons are pinched into a narrow channel missing the screen wires. When the CG becomes less negative the velocity of the electrons will accelerate causing them to miss the screen. Both effects significantly reduce screen current in beam type power tubes.

How about secondary emissions which can exceed the number of electrons impacting the plate?

The distance from SG to plate in beam tubes is increased. The extra area and concentrated beams form an electron cloud that simulates a cathode preventing the secondary electrons from reaching the screen even when the plate voltage dips close to the screen voltage. This effect notably reduces screen current. Beam type tubes will have a slightly sharper knee than tubes with suppressor grids.

Operating parameters of Beam type tubes:

The operating parameters of beam type tubes tell you a great deal about their behavior, design limitations, and statistical probability of matched pairs. Not all vendors publish this information. RCA does and when RCA became Burle, the parameters were divided into 4 quadrants for some tubes notably the 8122. This enabled a designer to select a specific quadrant for AB1 linear operations knowing what output to expect, neutralizing configuration, and bias limits to use.

The reason for the following seemingly wide ranges is the CG and SG alignment and distance from CG to SG is critical. A perfectly aligned tube will have the lowest bias requirement and lowest inter-electrode capacity.

THE RANGE OF OPERATIONAL PARAMETERS FOR THE 6146 AND 6146b:

6146:

With plate voltage 300, screen voltage 200, and control grid -33 volts, the plate current can vary **from 45 to 83 ma.**

6146B:

With plate voltage 400, screen voltage 200, and control grid voltage -34 volts, the plate current can vary **from 46 to 94 ma.**

Those ranges are 2/1, so too is the range of bias to idle the tubes. The bias range for the 6146 is approximately -35 to -70 volts for most class AB1 transmitters --- For the 6146B notably higher.

WHAT ELSE DOES THIS RANGE TELL YOU:

A tube at the low end of the range will require the lowest bias setting to idle and have the lowest inter-electrode capacity. At the high end the highest bias setting to idle and highest inter-electrode capacity.

For AB1 operations the lowest idle bias tube will deliver the least power to the antenna even though it will equal the highest bias tube when running AB2 mode. We have had some of the highest bias tubes running AB1 mode reach max emissions before the control grid reaches 0 volts where AALC would have become active.

Hallicrafters and many other vendors sold tubes for their transmitters that were specifically selected to work in one of the four bias ranges that they were designed. This would enable a single or pair of tubes to be a close match and work to design specifications. The increased cost of the tubes was not simply to fund the company vacation plan.

Last thought: Beam forming plates are not unique to beam type tubes. A beam type tube is distinguished by the implementation of individual beam channels formed by precisely aligning the screen and control grid wires as seen in the previous photo.

NEXT: Why a transceiver that is neutralized on 10 Metres is not equally neutral on the lower bands. Please read (http://k9axn.com/_mgxroot/page_10873.html) first; It provides the background for the follow on.

Regards Jim K9AXN 11/6/2016
