ONLY FOR RENEWAL USE

1630

U-H-F ORBITAL-BEAM AMPLIFIER

The 1630 is a type of vacuum-tube amplifier designed for use at ultra-high-frequencies in the order of 500 megacycles. This tube is especially useful in those services which involve the transmission of a wide band of frequencies. The 1630 employs a unique application of focused electron beams to isolate the input and output electrodes, and a stage of secondary-emission multiplication is used to augment the high transconductance of the input electrodes. The name of the tube is derived from the shape of the paths of the electron beams, which resembles the motion of a planet around the sun.

The 1630 features low interelectrode capacitances and unusually high effective transconductance. In addition, the construction is of the acorn type with its small size and short leads having low resistance and low inductance. Two external connections are provided for several of the electrodes to make possible further reduction of lead resistance and inductance.

TENTATIVE DATA

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES:°		
Input (Grid No.1 to All Other Electrodes except Plate)	6	μμf
Output (Plate to All Other Electrodes except Grid No.1)	3.2	μμf
Grid No.1 to Plate	0.0005 max.	μμf
MAXIMUM OVERALL LENGTH	2-1/2"	
MAXIMUM DIAMETER	2-5/32"	
BULB	T-8	
TERMINAL CONNECTIONS	Special	

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

PLATE VOLTAGE	375 max.	Volts
DYNODE VOLTAGE	250 max.	Volts
OUTER FOCUSING ELECTRODE VOLTAGE	±25 max.	Volts
INNER FOCUSING ELECTRODE VOLTAGE	300 max.	Volts
SCREEN (Grid No.2) VOLTAGE	100 max.	Volts
SCREEN SUPPLY VOLTAGE	375 max.	Volts
PLATE DISSIPATION *	1.5 max.	Watts
DYNODE DISSIPATION **	0.6 max.	Watt
INNER FOCUSING ELECTRODE DISSIPATION	0.75 max.	Watt
SCREEN DISSIPATION	0.2 max.	Watt
TYPICAL OPERATION:		
Plate Voltage	375	Volts
Dynode Voltage	250	Volts
Outer Focusing Electrode Voltage	0	Volts
Inner Focusing Electrode Voltage	300	Volts
Screen Voltage	#	
Control-Grid Voltage (Grid No.1)	-1	Volt
Plate Current	11.8	Ma.
Dynode Current	-9.4	Ma.
Outer Focusing Electrode Current	0	Ma.
Inner Focusing Electrode Current	0.6	Ma.
Screen Current	0.32	Ma.
Cathode Current	3.5	Ma.
Transconductance (Grid No.1 to Plate)	15000	Micromhos

° With no external shield.
* Plate dissipation is plate current multiplied by (plate voltage minus dynode voltage).
** Dynode dissipation is dynode voltage multiplied by (plate current plus dynode current). Note that dynode current is inherently negative.
# Supplied through resistor of 1 megohm from plate supply of 375 volts.

ORBITAL-BEAM AMPLIFIER CONSIDERATIONS

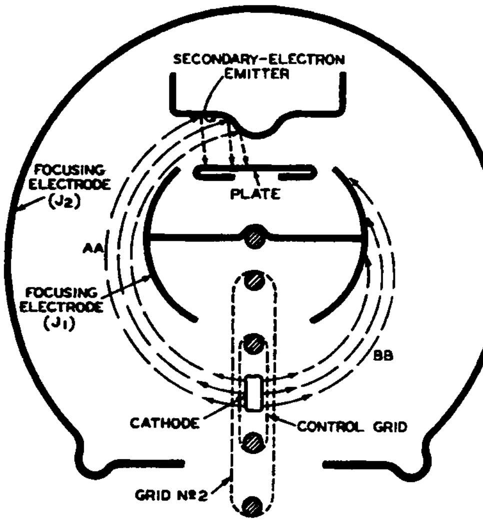
The problem of obtaining satisfactory amplification of a wide frequency band at the ultra-high frequencies depends to a great extent on the interelectrode capacitances, the transconductance, and the transit time and loading effects in the vacuum tubes used.

The amplifier tube's input and output capacitances must be low since they frequently are large parts of the total capacitance in circuits designed for ultra-high frequency applications. Circuit capacitances in turn govern the tuned coupling circuits between stages of an amplifier. Thus, the impedance of the tuned circuit in the output of an amplifier tube varies over the received band of frequencies, and this variation causes changes in the effective amplification. The amplification over a given band-width can be flattened by the use of shunt resistors in the tuned circuits. The arrangement causes reduced gain at the same time. For a given band-width, the larger the circuit capacitances (in the limiting case, the tube capacitances), the larger the shunt resistance and the lower the amplification. For this reason, the input and the output capacitances must be made low for ultra-high-frequency applications. From this discussion, it is apparent that low capacitances and high transconductance are desirable to maintain the amplification over a wide band of frequencies.

Transit time of the electrons in a vacuum tube between cathode and plate may vary for individual electrons because of the spread of their velocities and because they follow non-uniform paths. The net effect of these variations is a reduction of the tube's overall transconductance at the ultra-high frequencies since the separate contributions of the individual electrons are not in phase. The effect of transit time between cathode and grid may be serious input-circuit loading. To minimize this effect, the cathode-to-grid spacing is made extremely small.

Additional input loading may be caused by the inductance of the cathode lead common to the input and output circuits. Two cathode leads are provided in the 1630 so that separate returns to the cathode can be made for the input and output circuits.

In the 1630, the requirements outlined here are met to a remarkable degree. The arrangement of the electrodes in this tube is shown in the accompanying drawing. The distinctive features of the input electrodes are their small size and close spacing. High transconductance with relatively low capacitance are obtained in this manner. The electron stream from the cathode is formed into two well-defined beams by the shape of the electrodes, by their spacings, and by their



Schematic arrangement of Type 1630 structure

applied voltages. Under the influence of the electrostatic fields of two electrodes, designated G_3 and G_4 in the tube symbol diagram and as J_1 and J_2 in the schematic cross-sectional view, the two beams are accelerated and focused on a secondary-electron multiplier, or dynode. The secondary electrons produced are attracted to the output electrode, the plate. In the tube symbol diagram, these two electrodes are shown as grids, rather than deflecting electrodes, since their primary functions are those of acceleration and focusing of the electron beam. The two electrodes, G_3 and G_4, also serve to isolate the plate from the control electrode (grid No. 1) so that the grid-plate capacitance is low. The potentials of these electrodes determine the paths of the electron beams. Under the usual conditions, the inner electrode is operated at a positive potential while the outer electrode is at zero potential, with the result that the beam is focused on the dynode. It is possible, by the variation of the potential of the outer electrode, to change the paths of the beams (as indicated at BB in the drawing) and, thereby, to control the plate current without changing the cathode current. This feature is valuable since the control of gain is obtainable without causing changes in input capacitance and inductance. In the 1630, the use of well-defined beams, and close and uniform spacing of the input electrodes contribute to the overall efficiency of the tube at the ultra-high frequencies.

INSTALLATION and APPLICATION

The *terminals* of the 1630 may be held by a special 12-contact socket, such as the RCA stock No.9916, which may be mounted to hold the tube in a vertical position or with terminals No.2 and 8 in a horizontal plane. Do not attempt to solder connections to the terminals as the heat of the soldering operation may weaken and even crack the bulb seal.

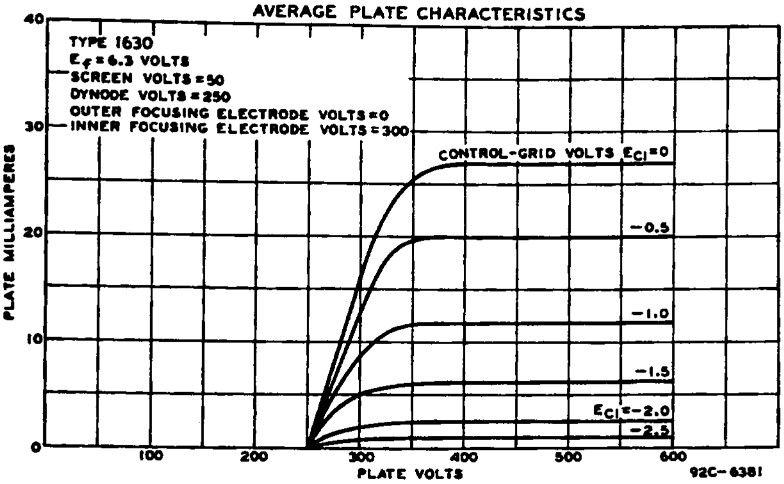
The *heater* voltage, under any condition of operation, should not vary more than ± 10% from the rated value of 6.3 volts. Conventional heater-cathode circuits may be used.

The *d-c voltages* for the electrodes, except for the screen (grid No.2) voltage, should be obtained from a voltage divider across the high-voltage supply. The design of the divider should take into consideration the fact that the dynode current is inherently negative. The screen voltage may be obtained through a voltage-dropping resistor from the high-voltage supply.

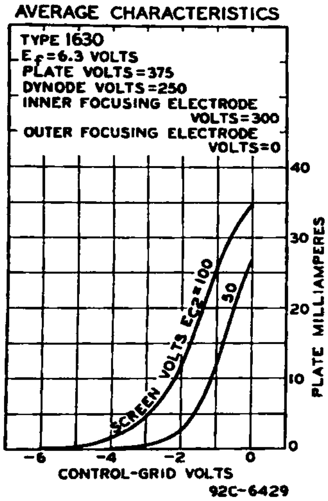
The arrangement of the leads of the 1630 is such as to provide the maximum isolation of the input and output leads, electrodes, and circuits. In addition, the double leads of each of several electrodes facilitates the reduction of lead inductance and resistance. Except for the grid and plate, each electrode terminal should be by-passed to an r-f ground by means of condensers. At the higher frequencies, it will usually be advisable to supplement the action of the condensers by r-f chokes placed close to the condensers.

RCA-1630 may be operated as an amplifier under conditions not to exceed those given under MAXIMUM RATINGS. A practical circuit for use of the 1630 at the ultra-high frequencies consists of two concentric cylindrical transmission lines placed on opposite sides of the tube socket and connected to the grid and plate. Both lines are tuned by sliding short-circuiting bars. The design of these lines must take into account the length of the tube leads and the tube capacitances.

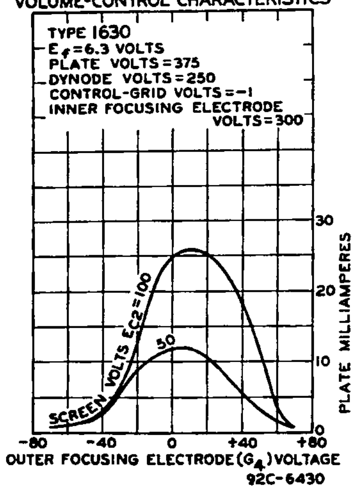
AVERAGE PLATE CHARACTERISTICS

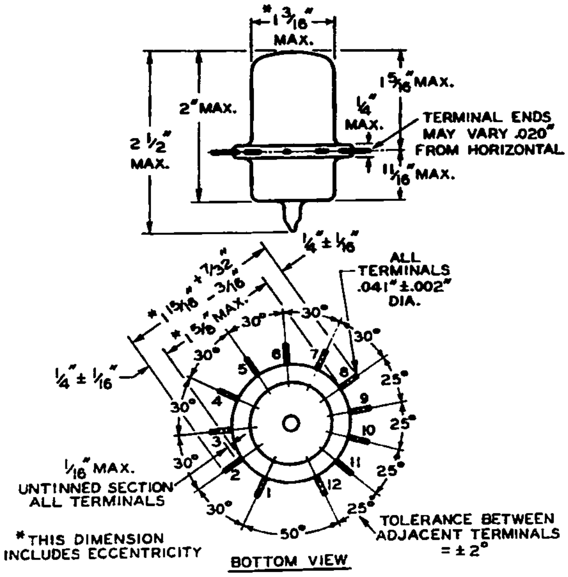


AVERAGE CHARACTERISTICS



AVERAGE VOLUME-CONTROL CHARACTERISTICS





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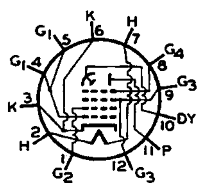
Bottom View of Socket Connections



H = Heater
K = Cathode
G_1 = Grid No.1
G_2 = Grid No.2
G_3 = Inner Focusing Electrode
G_4 = Outer Focusing Electrode
P = Plate
DY = Dynode